Muscle Monitor

User Guide

Muscle Monitor (Version 3.1)
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MYONTEC LTD - https://www.myontec.com/muscle-monitor

CONTENT

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WHAT IS MUSCLE MONITOR?

Muscle Monitor takes the Mbody family to a new level and it is better tailored to the needs of professionals who want more information with greater accuracy.
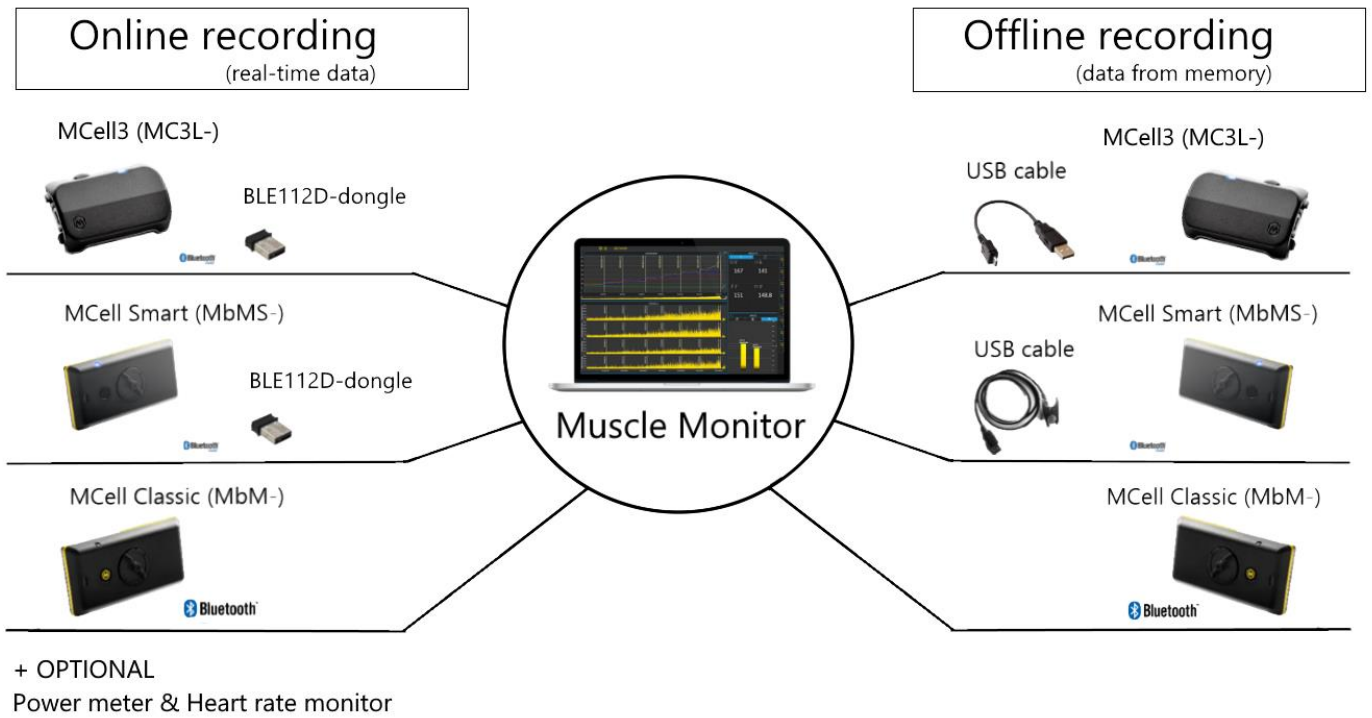

Muscle Monitor supports both, online and offline recording for analysing muscle activity. Additional data can be imported and merged to muscle based data. Data can also be exported for even further analysis.

HARDWARE REQUIREMENTS

PC Requirements:

-Windows 7 SP 2, 8.1 or 10

-.NET Framework 4.5

-"BLED112 -Bluetooth Smart dongle" for Bluetooth Smart devices

-MCell Classic: Bluetooth connection for data transfer (v2.1 + EDR or higher)

-Processor type Intel Core i3, AMD A6 or equivalent (Core i5 or AMD A8 recommended)

-Processor speed of 1.6 GHz

-2GB of RAM, 4 GB recommended

-100+ MB of free HDD space

HARDWARE SETUP

Online recording
(real-time data)

MCell3 (MC3L-)
BLE112D-dongle

MCell Smart (MbMS-)
BLE112D-dongle

MCell Classic (MbM-)

Muscle Monitor

Offline recording
(data from memory)

MCell3 (MC3L-)
USB cable

MCell Smart (MbMS-)
USB cable

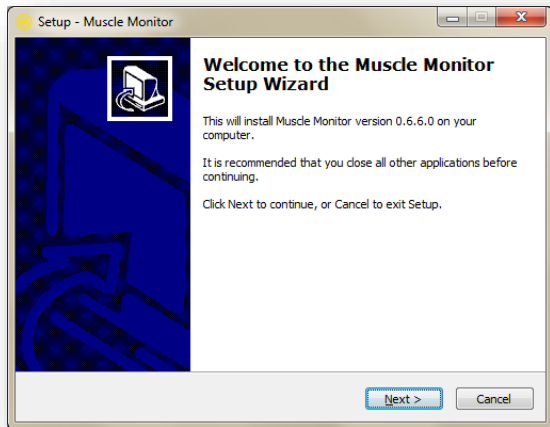MCell Classic (MbM-)

+ OPTIONAL
Power meter & Heart rate monitor

For more information on smart clothing, the basic use of the products and a detailed FAQ section, see the General User Guide on the Myontec website.

INSTALLATION

Open the "MuscleMonitorSetup.exe" *Note:* You may need to have **admin** privileges for this.

The setup wizard pops up:

Click "Next". The installer asks for installation folder. Type the folder you wish the software to install or click "Next" again to install to default folder.

Now choose the folder for Start menu shortcuts. Click "Next" to set default folder. Finally, click "Install" to start the installation.

After installation you are prompted to install the Bluetooth and USB -drivers. It is highly recommended that you allow the drivers to install.
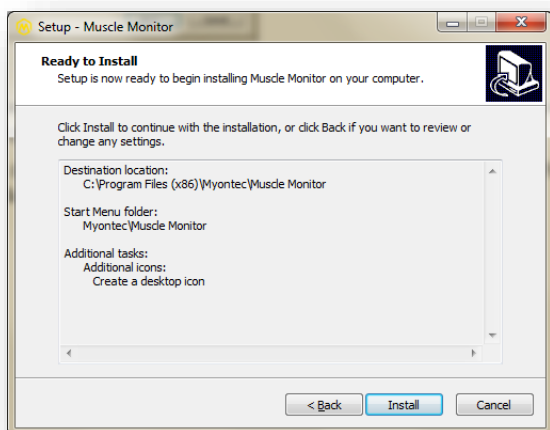
After the installation click "Finish" and you are done!

HOW IS THE MUSCLE ACTIVITY MEASURED?

The muscular activity is measured using conductive textile sensors to collect the signals through the skin above muscles. The scientific method is called electromyography (EMG).

µVs	MA	MA/min
1	0,01	0,6
10	0,1	6
100	1	60
1000	10	600

From a technical point the EMG is measured in microvolt (µV) at 1000Hz before any signal is processed further. Since Myontec products are intended for a variety of uses, the results must be presented in different forms.

– Units µV and mVs ("microvolt" & "millivolt second")
It is an accurate unit and is often used in scientific reports and publications. All current EMG signals are shown in µV units. The cumulative work/load results are given in mVs units, e.g. like the total muscle load (it is calculated as follows, all 6 channel values [µV] * time [s] / 1000).

– Unit MA/min and MA ("muscle activity/min" & muscle activity")
It is a more practical unit and often used together with other variables such as heart rate, speed, distance, cadence or power. The unit "MA/min" describes the momentary average muscle load per minute; similar to heart rate "beats/min" and shares the same range like the other variables. In Mbody Live 3, the numerical value of the variable is calculated from the 4 channels of quadriceps and hamstring with a conversion factor of 0.6. Cumulative work/loading results are presented in MA units (average MA/min value * time).

Go to 'Settings' and then 'Preferences' to change the unit for the Live and Post Analysis view.
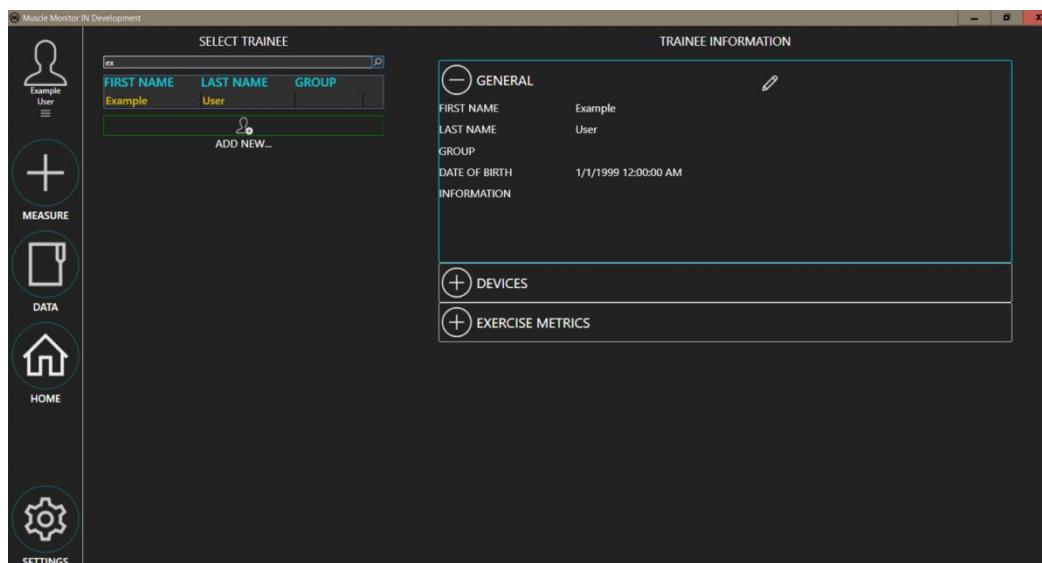
USING MUSCLE MONITOR

HOME SCREEN

In the start view of the software, the options 'Trainee selection', 'Measure', 'Data' and 'Settings' are shown on the left. Each of the sections is explained below. For a quick start, see 'Quick Start' on page 31. However, it is recommended to take a look at the user manual.

In the upper right corner an info-button can be found. It contains a link to the Muscle Monitor resource site and information about updates. On the home screen also information about the license and the status of BLE112D-dongle are shown.
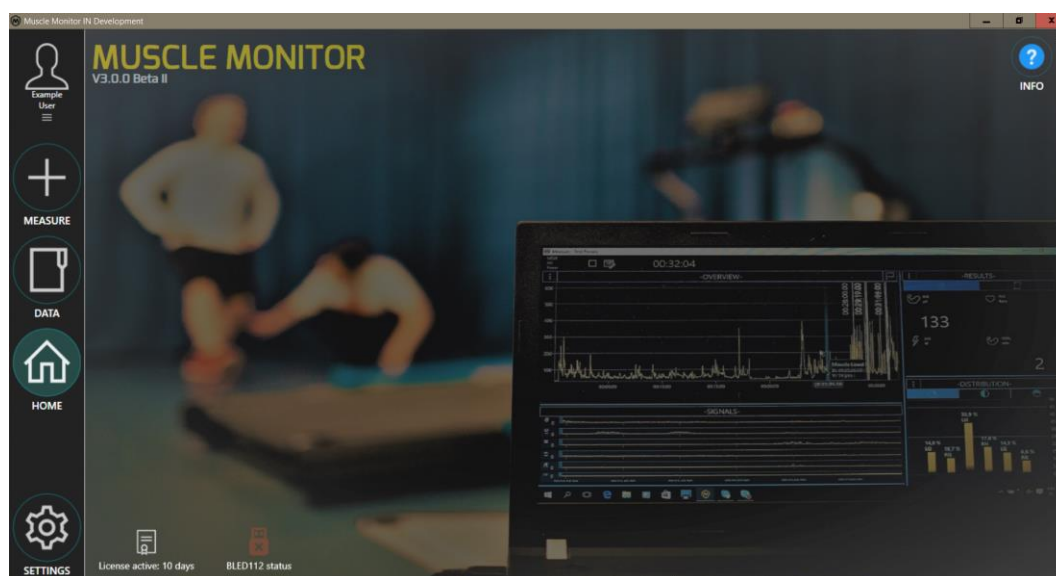

TRAINEE SELECTION

All data is stored to the selected **_trainee_**. Therefore, most actions in Muscle Monitor require that a trainee is preselected. Click the trainee selection button at the very top left corner to access the page. From there, you can select, edit or remove existing trainees or add new ones. By default, this list contains only example trainee.

Click 'Add New...' to create a new trainee. A new dialogue pops up.
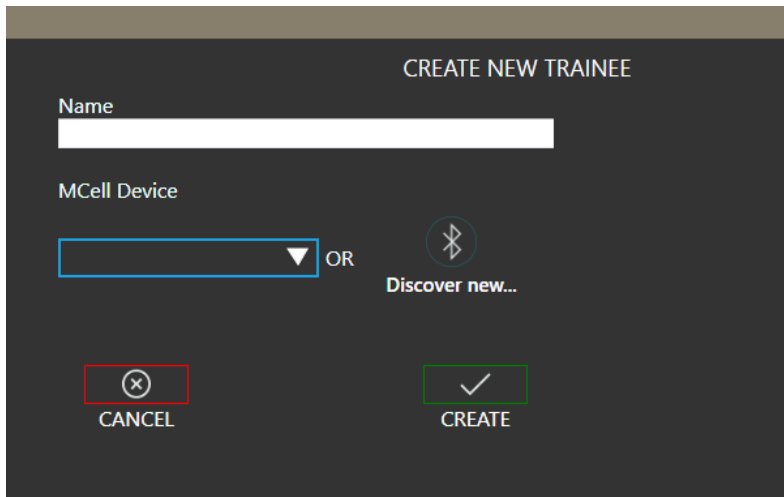
Simply, fill out a name for the trainee and select preferred MCell device. If you have not yet paired any devices to the software, you can 'Discover new' devices. Discovery is further explained under 'Devices' on page 27. Click 'Create' to finalize creation.
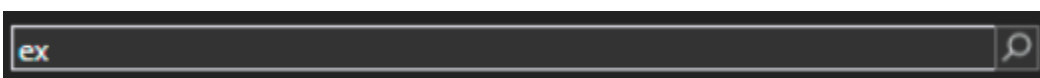
After creating a new trainee, it should be highlighted and selected in the trainee list. Edit trainee properties on the right side of screen. Use the pen-icon to edit and disc-icon to save any changes.

The 'General' section contains common information to describe and differentiate the trainee. These are not mandatory.

'Devices' sections contain device information, which is used when making new real-time measurements. Make sure you have the correct devices selected for the trainee!

'Exercise Metrics' has exercise and trainee specific information and parameters that can be utilized to better analyse the recordings like muscle fatigue threshold (MFT) and individual thresholds. See Appendix 1 for more information on setting MFT and thresholds.

It is possible to filter trainees by using the text bar above the trainees.

Trainee information

ONLINE RECORDING

After you have selected a trainee, 'Measure' is enabled at the left navigation column. Click 'Measure' to open the configuration page where you can set up your upcoming measurement. In the 'Devices' section you will be asked to choose the parameters you want to include. Heart rate monitor and power meter are optionally available. You can also choose exercise type and target training zone to better specify your exercise. Target zone will be shown in the Live view. The chosen interface influences what type of view is shown during exercise. Autolaps can be used to set automatic markers at specified intervals. You can set the interval under 'Settings' and 'Preferences'. Move the mouse pointer over the info boxes to get more detailed information about the selection.

Revise the settings at the right and start the measurement by clicking 'Start'.

Note: You can have up to three simultaneous online measurements at the same time (see 'Multiplayer monitoring' on page 21 for more information).

Note: According to Bluetooth standard the transmission works well within a distance of 10m. Make sure that there is a direct signal path from the MCell to the receiving device. Based on our experience, a distance of up to 30m is possible in indoor environment.
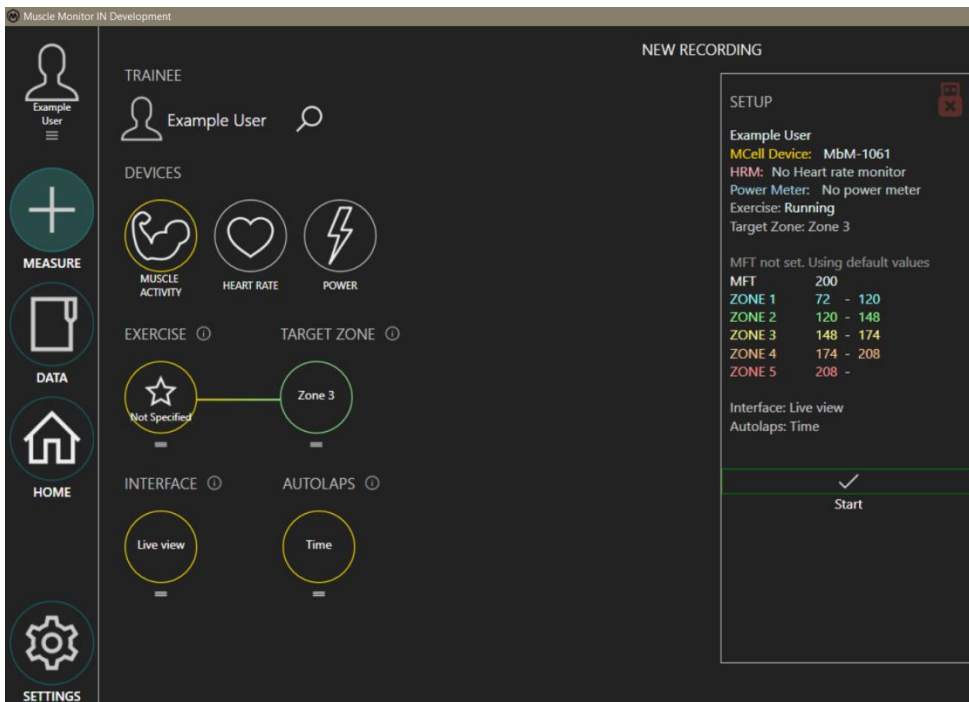
Online recording overview

INTERFACE: RESEARCH VIEW
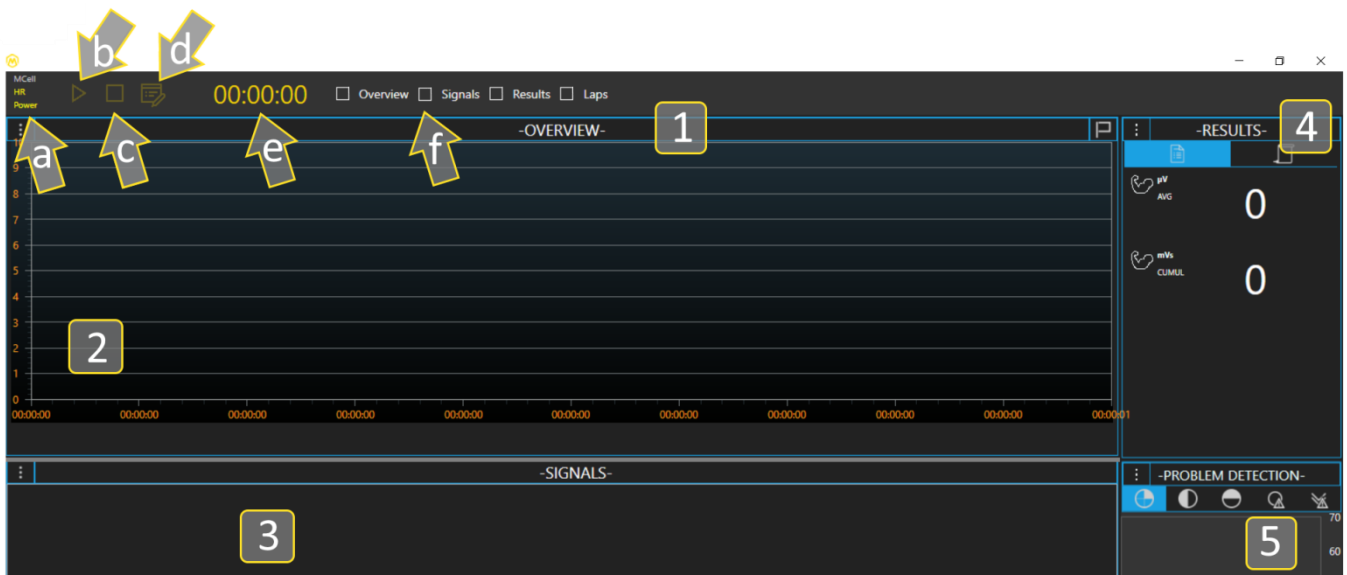
Main view of real-time measurement

1. Toolbar
   a. Device indicators: green = connected; yellow = connecting; red = connection lost; grey = not in use
   b. Start the measurement
   c. Stop The measurement
   d. Toggle Show / Hide notes
   e. Duration
   f. Show/hide charts
2. Overview Chart
3. Signals Chart

4. Results view
5. Problem Detection Chart
6. Lap List

NOTE!
The MCell connection is required for the measurement to start!

OVERVIEW

The 'Overview chart' offers a simple overview of the measurement. This XY-chart provides information about a variety of variables.

Press the three dots in the top left corner to open a menu in which view and the variables can be individually adjusted. Markers can be added in the middle of the view by pressing the flag in the upper right corner (post-analysis). In addition, you can adjust the axes and zoom into the view.
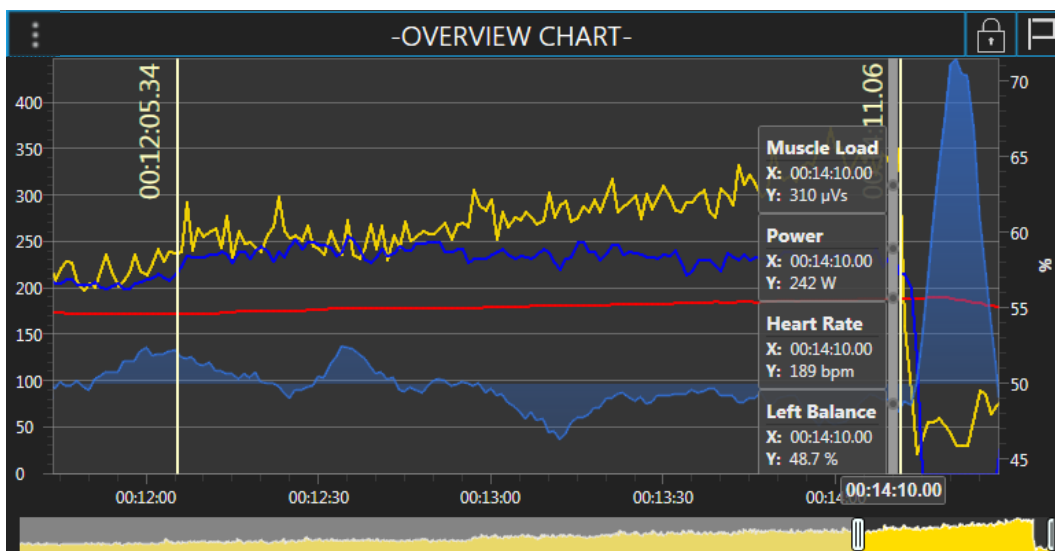
Post Analysis view of the Overview

Chart Variables:

Muscle Load: Shows the average 1Hz values from Muscle Load which is calculated from sum of all channels

Heart Rate: Shows the heart rate in bpm. Requires external heart rate monitor, see 'Settings'.

Power: Shows the Power in watts. Requires external power meter, see 'Settings'.

Cadence: Cadence is estimated from your Muscle activity. Try it in cyclic exercises.

Speed & Distance: Shows Speed in km/h and Distance in meters. Can be imported, see 'Importing data'.

Custom: Enables you to choose a ratio value of the main variables. E.g. calculate the change in Muscle load in relation to produced power, in each condition.

Balance & Ratio: Shows Balance Left/Right or Ratio Quads/Hams, respectively, of your muscle loading.

Muscle Group Balance: Shows balance from one of the measured muscle groups. The signal is coloured from green to yellow to red, depending how balanced the muscles are.

Zones: The Muscle Load zones can be overlaid to see in which zones the Muscle Load is moving. Note: The zones are sports specific and must be set prior to measurement.

SIGNALS

Signal control gives a view to data provided by MCell in a high precision manner. By default, each signal channel is drawn 25 times a second (25Hz). While similar in behaviour as the 'Overview chart', 'Signal chart' lets you zoom in for a rapid change in muscle activity. In the left upper corner you will find a menu where you can decide which of the data channels should be displayed.
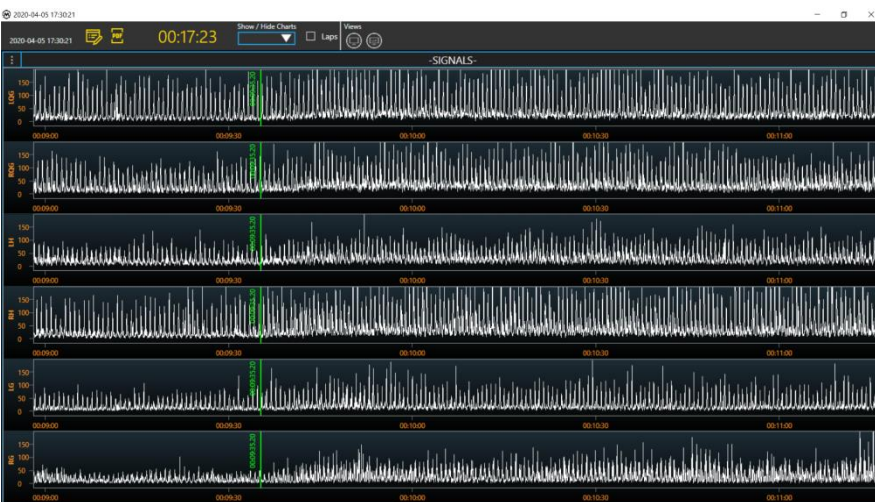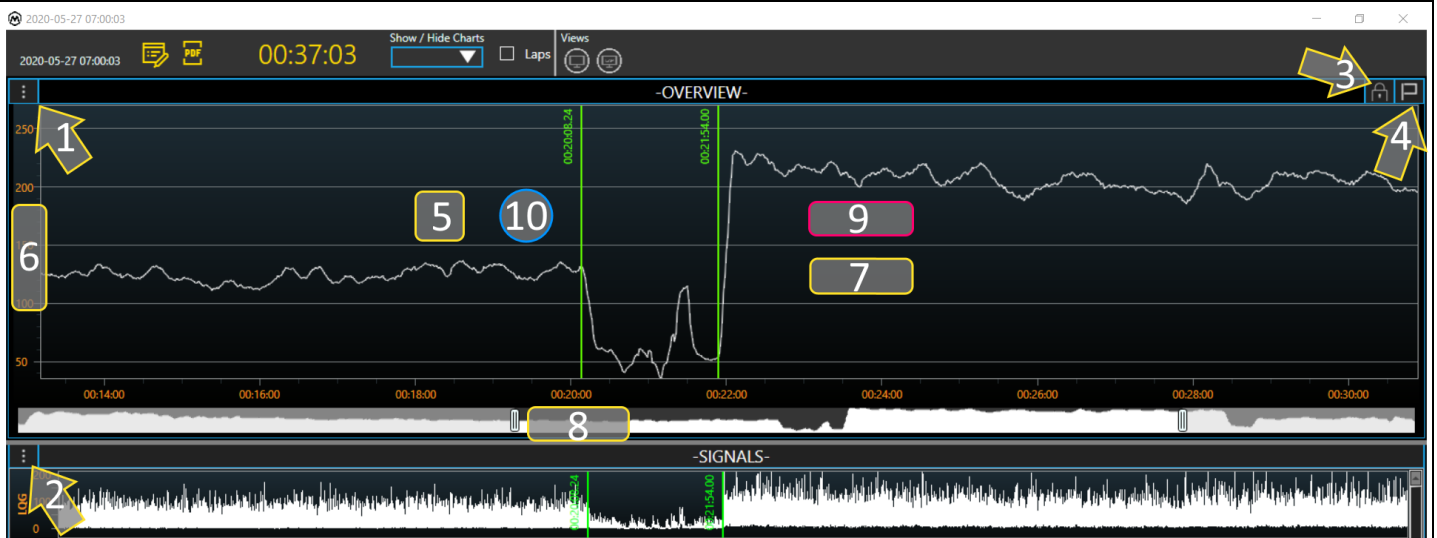

*3 minutes of data*

 5 seconds of data

Arrow = click, square = double click, rectangle = drag, circle = scroll

1. Overview - show chart settings
2. Signals – show chart setting
3. Unlock lap (then click lap and drag)
4. Add new lap
5. Double click to zoom to default
6. Drag y-Axis to change the min and max values
7. Drag to mark area of interest – values are calculated for this area
8. Drag icon to move through the recording

9. Drag signal (with right button) to move through the recording

10. Scroll to zoom in/out

All actions can be carried out both in the overview and in the signal chart.

RESULT WINDOW
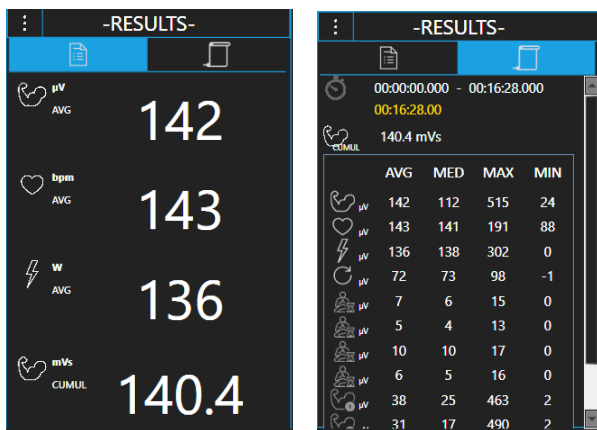
The Results view gives you the values in plain numbers. During online measurement this shows the latest values and all-time averages, while in post-analysis you get values from the selected area.

General view (shows average values of the main variables):

-Muscle Load

-Heart Rate

-Power

-Total Muscle Load: represents the sum of the measured activity from all EMG-channels during the selected part of the measurement

*List view (*shows average, median, min, max values from variables):

-Muscle Load

-Heart Rate

-Power

-Speed/Distance

-Total Muscle Load

-Channels data

-Cadence: Muscle load based estimation of cadence for repetitive exercises

-Relaxation: Shows how well the muscle relaxes during exercise, see 'Problem Detection chart'.

PROBLEM DETECTION

The problem detection charts show some data evaluations. The traffic light system enables easy understanding of the results. Green means that everything is normal; yellow indicates a trend towards a problem, but the result is still in an ordinary range, while red means that there is a problem. The origin of the problem should be defined and corrected to avoid an injury.

How to interpret the results?

Muscle group balance shows the difference of the muscle loading between the same muscle groups of both sides. The optimal result would be 50% for each muscle, but small differences between left and right muscles are natural. Below ± 4.5% difference (from 50%) the bar will appear in green. Between 4.5% and 9% the bar has a yellow colour and changes to red above a difference of 9%. There are lines in the graphic to illustrate this.

The *muscle distribution* shows how much each muscle contributes to the total muscle load. The colour calculation for this is bit more complicated. The total muscle load is set to 100% and the proportion of each muscle is calculated. For a smaller proportion, a smaller difference is enough to change the colour coding. But around the same difference values as with the muscle group balance are used.

For *side balance* the total muscle load of left and right side is calculated. In a steady endurance type symmetric exercise the optimal result would be 50%. A difference of ±4.5% is in a normal range. That goal is to keep both bars in between the lines. Note that during non-symmetric exercises the balance may show other values, which still may be "normal" for those exercise type.
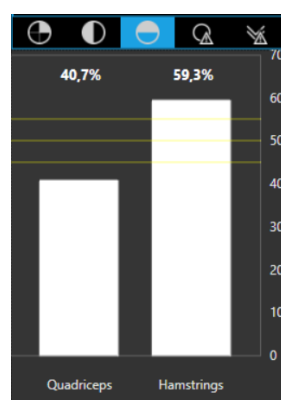
The *Q/H ratio* is only available for the Mbody shorts. For its calculation the muscle loading of quadriceps and hamstring from both legs are used. However, the quadriceps to hamstrings relation differs between sports and exercise intensities. For running the Q/H ratio should decrease with increasing speed. The optimal Q/H ratio during slower intensity endurance running is approx. 45/55% and approx. 40/60 % for higher speed running. When sprinting, the Q/H ratio can increase to 30/70% in well-trained sprinters. During cycling the Q/H ratio is closer to 50/50 % or quadriceps typically dominate hamstrings with few percentages.
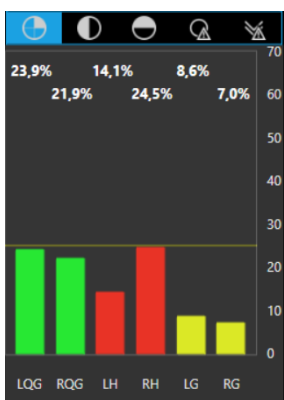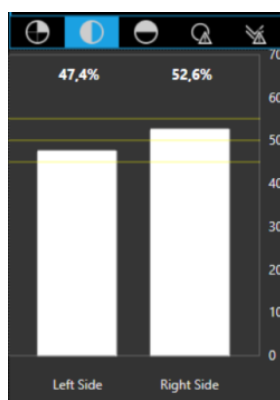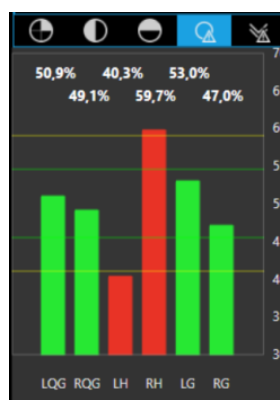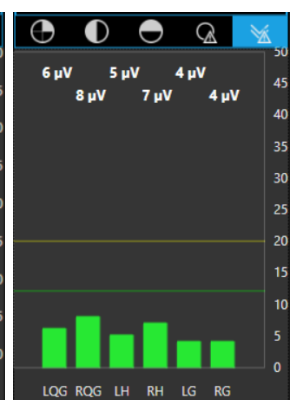

| *Muscle distribution* | *Side balance* | *Q/H ratio* | *Muscle group balance* | *Relaxation* |

The *relaxation* parameter can be used to monitor the level of relaxation and therefore the functional state of the muscles during training. It is possible to notice fatigue accumulation. The bar is green if the relaxation level is below 12 µV, which indicates proper relaxation, yellow for 12-20 µV, which means there is a tendency to impair muscle relaxation, and red if the relaxation level is above 20 µV, which indicates impaired muscle relaxation.

LAPS

Laps can be set during or after the measurement using the flag in the top right corner. A lap creates a summary of the following recording until a new marker is set or the measurement is ended. A lap can be marked as uninteresting with the thumb and deleted with the cross. It is also possible to add notes after or during the exercise.
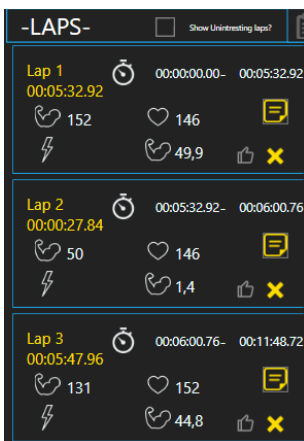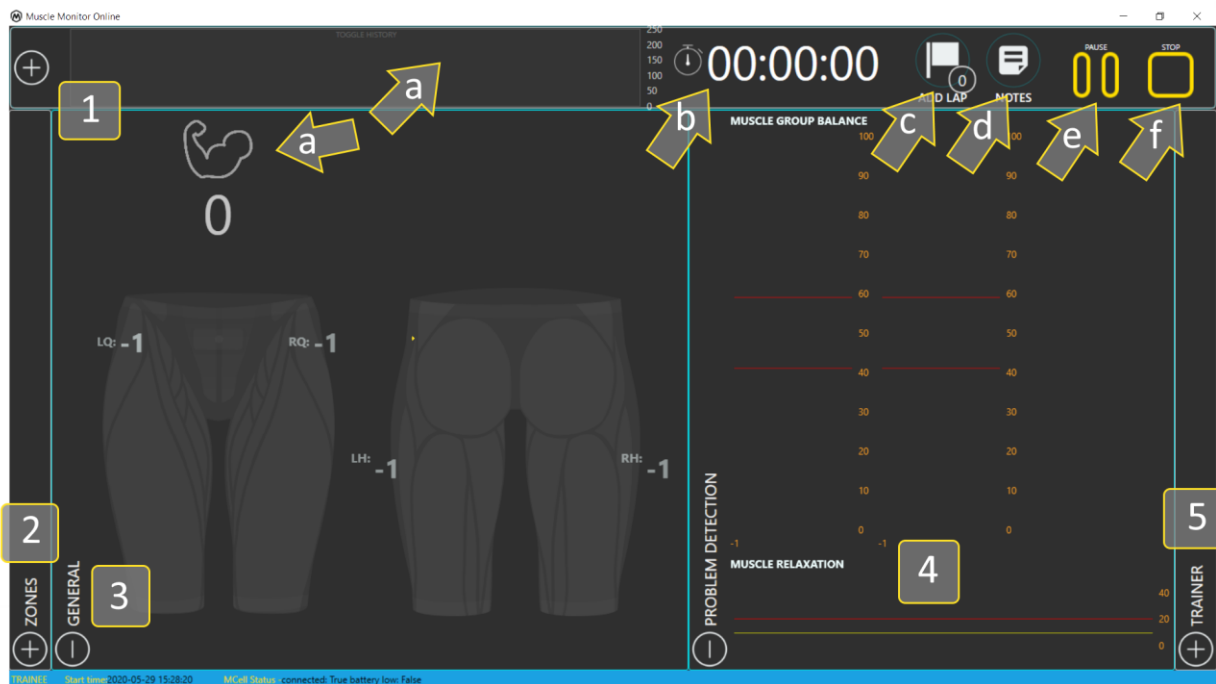

ENDING THE MEASUREMENT

After the measurement is done it can be stopped with the 'Stop' button. The 'Save' dialog appears which enables you to give a short description and sports to the exercise. When done, the measurement is saved and stored in your personal 'Archive'. Discarding the exercise removes all the data recorded.
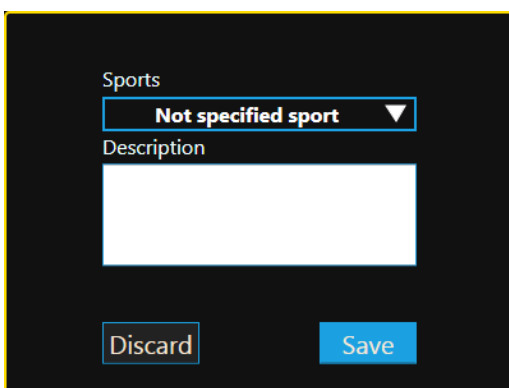
LIVE VIEW

1. Header bar
   a. Muscle Load overview
   b. Duration
   c. Add Lap-marker (hotkey: "space")
   d. Add notes
   e. Pause exercise
   f. Stop exercise
2. Zones
3. General parameters
4. Problem Detection
5. Trainer

By clicking the section headers, the sections can be shown or made hidden.

After stopping measurement in *Live view*, you are prompted to either store or discard the exercise and a summary of the exercise is shown.
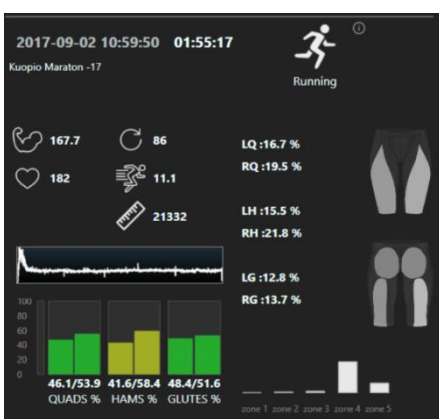
NOTE!

Saving: The save button saves the exercise files to .hex and .mdf file format which is standard for opening data with Muscle Monitor v3.1. If you wish to backup or move the data, these can be found from the folder path:

\Documents\Myontec\Muscle Monitor\userdata*User Name**Start Time*

MULTIPLAYER MONITORING

With Multiplayer monitoring you can have up to three simultaneous online measurements at the same time. For example, you can record EMG data from one person wearing multiple smart cloths or collect data from up to three athletes at the same time.

First, make sure that all MCells you want to use for the measurement are added to Muscle monitor (see 'Devices' on page 27) and the Bluetooth dongle is connected.

Go to 'trainee information', 'Devices', 'Select personal device' and select one MCell. Save the selection. Next, go to 'Measurement' and click 'Start'. The measurement window will open. You can minimize the window, but keep it open somewhere. Now, you should go back to 'trainee information', 'Devices', 'Select personal device' and select the next MCell. It is either possible to use the same trainee or to create a new trainee for each device. Following these steps you can open up to three measurement windows. After you arranged the measurement windows, you need to start each recording separately.
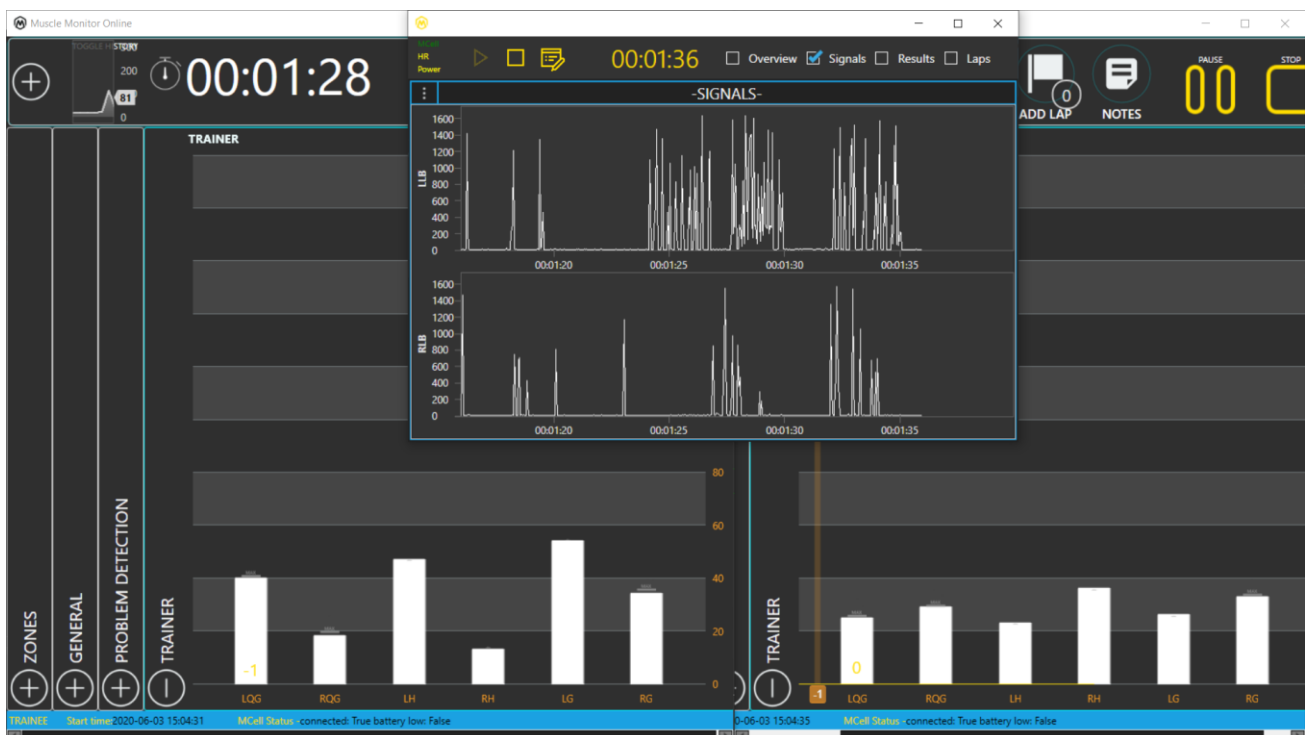
Example of multiplayer measurement (two Live view recordings combined with one Research view recording)

NOTE! For Multiplayer monitoring we recommend use of large external display with high resolution. You can also split the whole screen with all open measurement windows to see all data at the same time.

With offline recording you can have as many recordings as you want at the same time, but you will also have to start each MCell manually.

OFFLINE RECORDING

With offline recording, you can measure muscle activity under field conditions without the need for a nearby computer.

First, connect the MCell with the smart clothing. Then hold the button for two seconds until the MCell3 vibrates. The indicator light will flash green which shows that the MCell3 is recording. If you press the button for a short time it will set a marker.

For ending your measurement hold the button for around three seconds. The MCell3 will vibrate twice. The blue flashing light shows that the recording is finished.

There is no vibration with older MCell versions. For these devices the indicator light will change from a slow blue flashing to a faster flashing after the start of recording.

Further information on MCell and smart clothing can be found in the general user guide on the Myontec website.

Note: It is possible to use the Mbody Live 3 App together with offline recording. Therefore start the offline recording first and then the app.

DATA (POST ANALYSIS)

By pressing 'Data' from the main menu, you are brought to a new page. 'Data' has two sections selectable at the top header.

Data view

RECORDS

By default, file list view is shown when the archive is opened. This lists all the recorded data for the selected trainee. Search bar and tags can be used to filter exercises, when the list is crowded. Selecting a file pops up a brief summary of the selected file to the right side. When selected, a file can be loaded, edited or exported.

SYNC MCELL

The memory of MCell can hold data from offline recording which is compatible with Muscle Monitor. Select 'Sync MCell' from top row and follow the instructions to connect the MCell.

With MCell3 there is no need for pressing the button. If the connection fails, disconnect the USB cable briefly and try again.

After connecting all device data is listed with timestamp showing when the recording has been started. Also, when connected, the 'Device information' shows the device time, battery level and available memory. If the device clock has been reset, it is automatically synchronized with the current time.
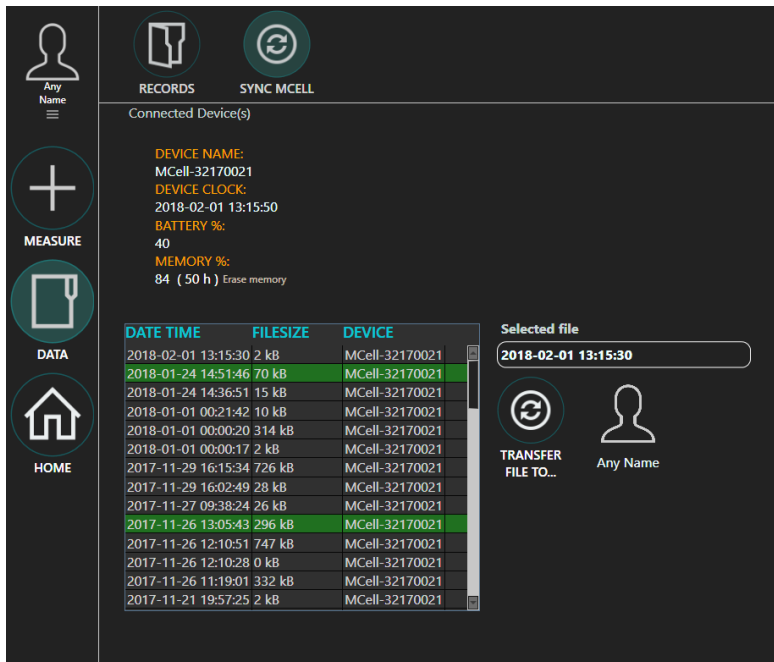
To transfer the selected file, press 'Transfer files to…'.

'Erase memory' removes all files from the memory.

NOTE! All files will be erased!

NOTE: If your MCell is type MCell Smart (MbMS-xxxxx) or MCell3 (MC3x-), make sure your device is connected to PC with the USB-cable before connecting.

NOTE: Make sure that the MCell device is switched on and is in idle state when connecting (blue led flashes once every three seconds).

NOTE: Under Memory, the available hours ultimately depend on the cloth configuration, which may vary and cause the estimation to be inaccurate.

OPEN FILE

With 'Open file' it loads up the file for further analysis. The main view was introduced in the chapter 'Real-time measurement, Research view'. During post analysis, the view has a few added controls at the top header:

In the top center the view can be changed to *Lap view*. This allows to compare parameters between laps more effectively.
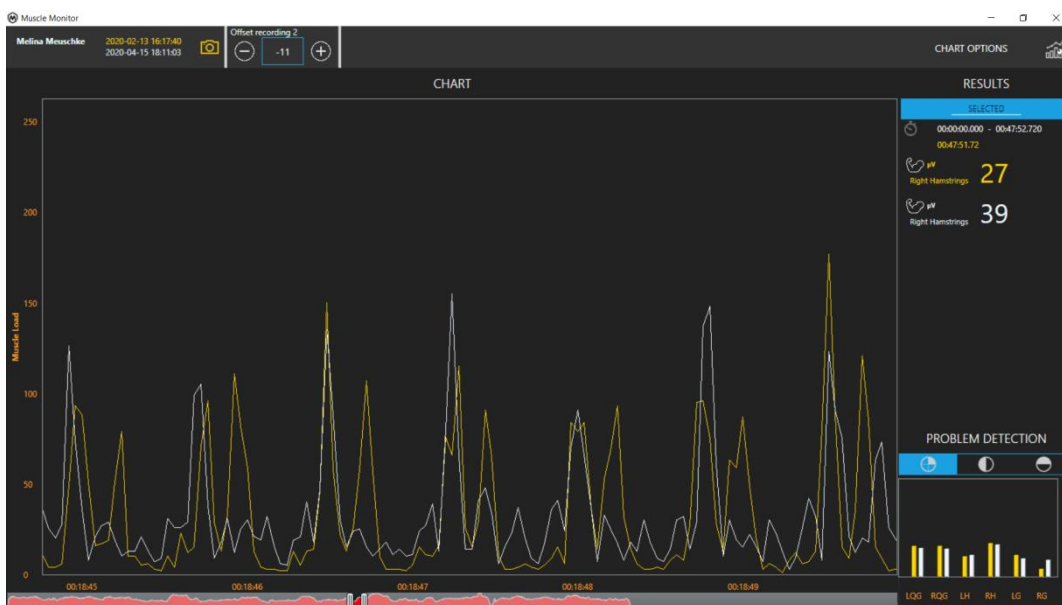

Lap view

LOADING MULTIPLE FILES

From the exercise list, 2 - 4 files can be selected by holding 'Ctrl'-key from the keyboard while selecting. When more than one file is selected, loading them opens up a slightly different *Comparison view*.

Comparison view

In the *Comparison view*, the data can be moved using the controls above. This shifts the data on the timeline so that the data can be synchronized with one another. The minimum offset is 1 sample, which will shift the recording by 40 ms for 25 Hz data.

In the upper right corner, the 'Chart options' button can be used to select shown data sources and edit the colours of the charts.

EDIT
When the file is selected, 'Edit' lets you change some of the information regarding the file.
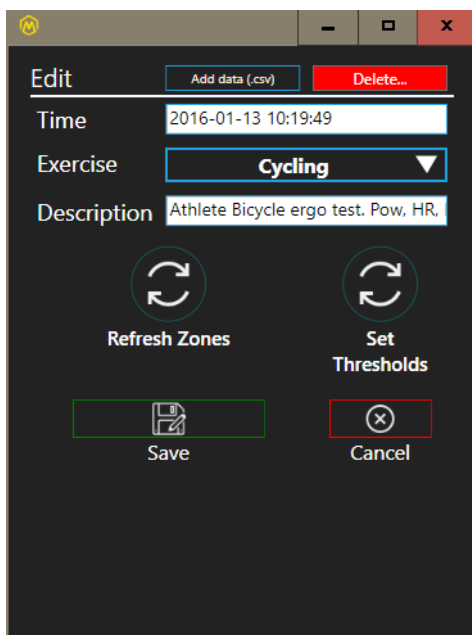
Edit view

- Time - Edits the timestamp of the file. Default is start time of the measurement
- Exercise - Changes the sports category
- Description - Edits the short description of the file
- Refresh Zones - Calculates and refreshes the MFT zone distribution based on selected exercise and current MFT.
- Set Thresholds - Refreshes the used Thresholds for selected exercise, based on the Thresholds set for the selected trainee.
- Delete - Deletes the file *permanently*!
- Add data .csv - Allows the adding of external data to the file.
  See Appendix 2

PDF REPORT
In the "Post-Analysis" view you can create and download a PDF report of your recording.

Therefore, click on the PDF icon in the header bar. Next, a document with an overview of muscle loading and lap specific problem detection results is created. You can either save the file on your computer or print it right away. See PDF report example in Appendix 5.
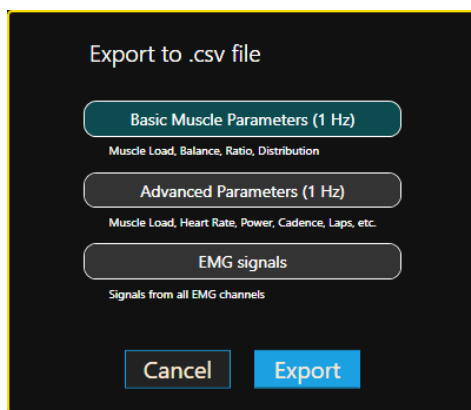
EXPORT

Export allows the exporting of file in CSV format. A few options on what data is exported are given:

- Basic Muscle Parameters- EMG-data, Muscle Load, Balance, Q/H ratio, Distribution
- Advanced Parameters – Laps, Duration, Muscle Load, Heart Rate, Cadence, Speed, Distance, Power
- EMG signals – Laps, all channel data (EMG-data. IMU-data, if synchronized accelerometer-, gyroscope-, magnetometer-data)

When 'Export' is pressed you are prompted to select a location for the file. Default folder is \Documents\Myontec\Muscle Monitor\exported\

All data is saved in CSV format with a semicolon ";" as a separator and first row as a header. These files can be opened e.g. in Microsoft Excel®.

SETTINGS

The settings are divided into three sub-sections: 'Devices' consists of external measurement devices which are essential for real-time measurements. 'Preferences' contains settings for some default and loading options. 'System' settings contain actions regarding the environment, such as localization. Content of these are briefly described below.

DEVICES

Three kinds of devices are supported. MCells to provide the muscle load based information. Heart Rate Monitors to add the heart rate information and Power Meters to add watt power. For the heart rate measurement a Bluetooth HR belt (BLE or Bluetooth Smart) should be used.

To add a new device, Press 'Add…'. A new scan dialog is opened and searches any Bluetooth devices nearby. Make sure that your device is powered up before initiating a scan! All supported and found devices are listed and can be *selected* and *saved*.
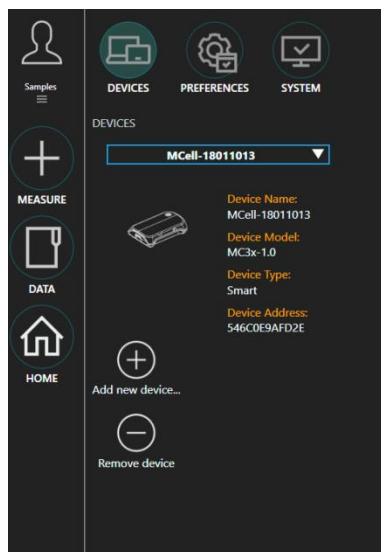
NOTE: For MCell Classic (MbM-xxxx) - After saving the device, the software establishes a test connection to the device. During the testing, Windows pops up a notification. Click the notification and proceed with given instructions to allow connection to happen. After, Windows also installs the default drivers for the device.

If you wait the notification to disappear, the test connection will most likely fail and the saving has to be done again.

To connect MCell Classic device you need to activate Bluetooth on your computer.
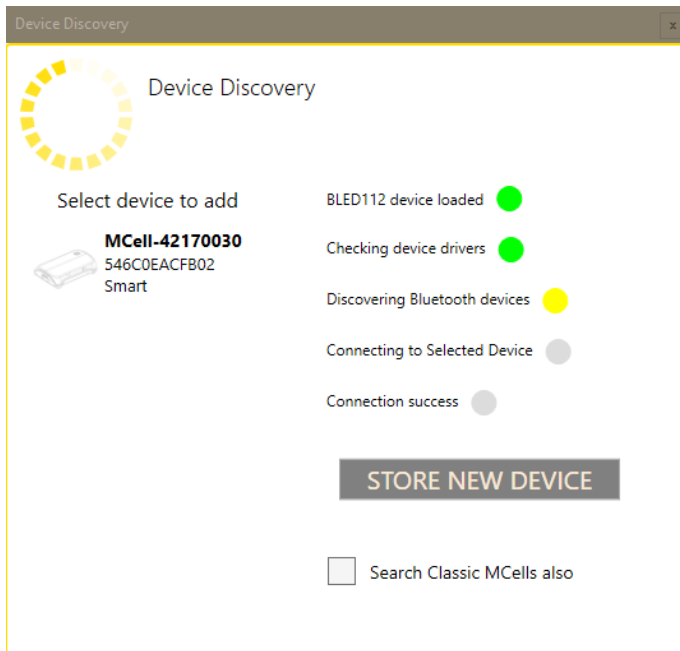
Scanning devices... Found one device

NOTE: After the device is saved, it is permanent and does not need to be done again. Device is added to all lists where device is prompted.

NOTE: All supported devices (excluding MCell Classic) use Bluetooth Smart connection and requires a BLED112-dongle to be attached to USB-port prior starting the software.

NOTE: Requirements for the Heart Rate monitor and Power Meter are: 1) It uses Bluetooth Smart for communicating. 2) It uses the standard Heart Rate / Cycling Power-Profile defined by Bluetooth SIG. Consult your device manufacturer for these.

To remove a device, simply select a device from the list and press 'Remove Device'.

FURTHER INFORMATION

FEEDBACK & SUPPORT

Resource and help site: www.myontec.com/muscle-monitor

Contact us by email: support@myontec.com

Or visit our website at www.myontec.com

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QUICK START

1. After installing the Muscle Monitor

-Plug in the BLED112 dongle

-Get you license key ready

-Start the software and insert license key when prompted. Internet connection required

2. Create trainee

-Click the trainee icon in the upper left corner

-Create a new trainee by pressing the 'Add' button

-Add a new MCell to the device list

-Add any optional HRMs or Power meters

3a. Start a new online measurement

-Click 'Measurement' from the main page.

-Make sure your selected devices are powered on and click 'Start'.

-Finish your exercise and click Stop and Save. Give description if needed.

3b. Download offline data from device memory

-Click 'Data -> Sync MCell' from main page

-Connect MCell via USB cable

-Press 'Connect' and choose data from list. Press 'Transfer'.

4. Analyse

-Find your exercise in 'Data'.

-Open and analyse.

TROUBLESHOOT

1. I CANNOT FIND MY MCELL DEVICE WITH SCANNING?

-Check that your MCell is powered up

-If it is an MbMS- or MC3- device, check that your BLED112 dongle is connected to USB-port before starting the Muscle Monitor and that the BLED symbol on the Main-window is green.

-If it is an MbM- device, check your Bluetooth adapter; Minimum specification for that is Bluetooth 2.1 + EDR that runs a Microsoft Bluetooth stack

2. I STILL CANNOT FIND MY MCELL SMART DEVICE WITH SCANNING?

-Go to Windows Device Manager

-Search for "Ports" and if there is a "Bluegiga Bluetooth" device listed when the dongle is plugged in.

-If the device is not correctly installed, re-install the drivers. Point the location of drivers to Muscle Monitor installation folder.

-Always make sure that the dongle is attached to USB before starting the software.

-Make sure you use only one dongle in each PC.

-See Appendix 3 for more in-detail steps.

3. HOW CAN I GET SUCH PARAMETERS AS SPEED OR DISTANCE TO MY DATA?

While you cannot at the moment get any real-time data from any device that adds speed or distance, there are two ways these are supported:

-Import 'Mbody Live data from Android phone'

-Add custom data to existing measurement

Details on these are explained in Appendix 2: "Importing Data"

OTHER QUESTIONS

- I have a license for the Muscle Monitor. Can I use it with different PCs?

No. The licenses are user/PC specific. Please contact sales if you need more licenses.

- I uninstalled and re-installed the Muscle Monitor. How do I activate my license again?

Normally you can re-install and update the software without needing to activate the license again.

- I have activated the Muscle Monitor, but now the software asks me to activate it again, what happened?

Normally Muscle Monitor stores some license information to users \Documents\Myontec\MuscleMonitor-folder. If the content in that folder changes or is removed, the software might ask the user to activate license again.

- I am trying to activate a license I have activated earlier. I am getting an error saying that it cannot be activated again. How can I re-activate the license?

An activated license normally can't be reactivated. Please contact the support with your license key and briefly state why the key has to be activated again.

- How can I back-up the measurement files?

Locate the data folder at \Documents\Myontec\Muscle Monitor\ the folder '\userdata' contains all the user and measurement information. Copy the contents of that folder to a safe place.

KNOWN ISSUES

In rare cases, when starting the software, a message saying that UISettings.dat is causing an error, pops up preventing the start of the software.

Solution: Something has caused the file to corrupt. Locate Muscle Monitor data folder at: \Documents\Myontec\MuscleMonitor and remove the UISettings.dat file. The file is regenerated at the next start of the software.

In some cases, when a new real-time measurement is started and it fails to connect to MCell (e.g. due to MCell not powered up), a background process is created, which also causes the subsequent attempts to fail.

Solution: Either restart the PC and the software or manually shutdown background processes named 'Muscle Monitor'. You can shut them down from the Task Manager -> Processes (Hotkey: Ctrl + Shift + Esc)

Appendix 1   MFT

WHAT IS MFT?

MFT is short for Muscle Fatigue Threshold. It is an endurance discipline specific parameter which is used for individual analysis and to set training zones.

More detailed explanation of MFT:

In order to individualize training intensity control tools are needed. Two common known parameters are ventilatory and lactate threshold. Both can be used to describe the anaerobic threshold (AT). AT is important for long-term performance ability as it represents the highest performance intensity that can be tolerated for relatively long periods. If the threshold is exceeded, the accumulation of lactic acid in the muscles can lead to fatigue in a short time. Generally speaking, AT is a steady-state effort that you could perform for hours. In scientific terms, AT is the point during exercise at which the main metabolism switches from aerobic to anaerobic.

The change in muscle function at anaerobic threshold (increased activity in type II muscle fibres leads to an increase in electrical activity of muscles, Peinabo et al. 2014) supports the idea that the threshold can also be identified with EMG. Tikkanen et al. 2012 showed that it is possible to use Myontec Mbody Shorts to predict the AT during running. Since it is measured with EMG, it is referred to as muscle fatigue threshold (MFT).

The MFT is a useful measure for deciding exercise intensity for training and racing in endurance sports and based on it we developed 5 training zones. MFT can also be used to track your performance development.

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
36-60 %	60-75%	75-88%	88-103%	103% - Max

based on MFT

	Intensity level	Purpose
Basic endurance		
Zone 1	Very light/Recovery	Warm-up, cool down, recovery
Zone 2	Light	Comfortable, easy breathing, light sweating, fat burning, can continue for hours
Speed endurance		
Zone 3	Moderate	Light muscle fatigue, still easy breathing, moderate sweating
Zone 4	Hard/Threshold	Muscular fatigue and heavy breathing when continued for longer periods: Recreational - at threshold up to 1 h Athlete - at threshold up to 2 h
Maximum endurance		
Zone 5	Very hard/maximum	Very exhausting for muscles and breathing, can maintain only for short intervals

For more information, see articles about MFT and training zones on the Myontec website.

HOW DOES THE MFT TEST WORK?

The MFT test has to be done discipline specific. Therefore Muscle Monitor offers three different MFT tests:

- General MFT test (sports independent)
- 6x1km test (running)
- Incremental ergo test (cycling)

For all tests Mbody shorts and MCell as well as HR monitor or power meter/bike trainer are needed. We recommend using a heart rate belt with display unit (watch or phone) during the test. Make sure to know your HR zones before you start the measurement (see calculation on the next page). Please use them to monitor heart rate during the MFT test.

General MFT test:

Warm-up period (at least 15 min)

Exercise at comfortable, low intensity with HR within the warm-up target zone. If the exercise is running, the intensity can even be brisk walking.

Muscle effort period (10 min)

Immediately after the warm-up start the effort phase. Keep the exercise intensity within HR target zone during the test period. Intensity should make you sweat and your breathing should get heavier, but you should feel that you could keep exercising with the same intensity at least for 20 minutes more.

Calculate HR target zones using following example:

Age (y)		28
Known or estimated HRmax (bpm) (Estimate 205-0.5*age)		191

(In that sport you are about to perform. Note that you typically achieve 5-10 bpm lower MaxHRs in cycling compared to running and skiing.)

Warm-up target HR area (0.67 * HRmax ± 5 bpm)	123-133

Activity level	**RECRETIONAL** 0.85 * HRmax ± 5 bpm	**ATHLETE** 0.90 * HRmax ± 5 bpm
Threshold level target HR area (bpm)	157-167	167-177

6x1km running test:

This test consists of six intensity levels, 1000 m each, from very light intensity until maximal running. Heart rate (HR), muscle loading and running speed increase progressively from

one level to another. If you are a recreational, you can shorten the running distance to 800 m. Conduct the test on track or flat terrain to avoid muscle overloading due to uphill/downhill etc. environmental factors.

The target HR for the 6x1km incremental running test is affected by the maximal HR. (Target HR (±5 bpm): 60%, 70%, 80%, 90%, 95%, 95%+ of max HR)

		Max HR (bpm)							
		175	180	185	190	195	200	205	210
Target HR	Level 1	110	115	120	125	130	135	140	145
	Level 2	125	130	135	140	145	150	155	160
	Level 3	140	145	150	155	160	165	170	175
	Level 4	155	160	165	170	175	180	185	190
	Level 5	165	170	175	180	185	190	195	200
	Level 6	175	180	185	190	195	200	205	210

Start with speeding up mildly to raise your HR to Level 1 target HR (± 5 bpm) and keep up that constant light loading level for 1000 m. This first phase is the warm-up so the actual test starts from level 2. Continue likewise without stopping until you reach Level 6. During Level 6 you do not need to check your HR. The aim is to run Level 6 with increasing speed so that the final stage is run at maximal effort

Incremental Ergo test:

The incremental cycling test is a resistance (power) guided exercise test. Therefore you need a power meter or bike trainer to detect cycling resistance (power, W). It is highly recommended to use an electronic trainer where test protocol can be preprogramed and which can control resistance regardless of your cadence or gearing selection. If that is not possible, increase power manually and keep the cadence constant. There are separate test protocols for male and female athletes in order to ensure appropriate test duration (12-30 min).

Start your bike trainer's test protocol and concentrate on pedalling as easily as possible with your constant preferred pedalling frequency (70-105 rpm). Continue pedalling as long as you can. Start the test with very light intensity (60W for men, 50W for women) and increases the resistance every two minutes until exhaustion (+30W men, +25W women).

HOW TO SET MFT IN MUSCLE MONITOR?

First, run the MFT test that best suits your discipline. After the test, you need to specify your exercise. Go to 'Data', click on the correct file and then on 'Edit file information' (pen

in the top right corner). A window opens in which you can define your discipline. For example, if you did the 6x1km test, choose running.
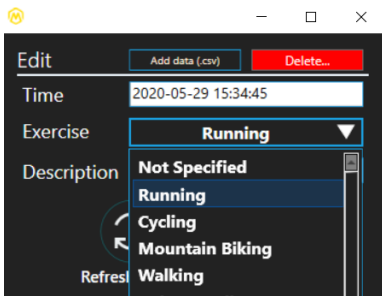
For the MFT calculation markers are needed. You can either set them during the measurement by briefly pressing the MCell button or afterwards in Post Analysis. Therefore, open the file and make sure that the overview is shown. Click on the Lock-button to release the Marker-function. A new lap is created in the middle of Overview-window by clicking the flag-button and you can manually move the marker by dragging the marker the correct position. You can also move or delete markers that were set during recording. The following markers are required for the various MFT tests: General test - start of warm-up period, start of effort period; 6x1km test – start and end; Cycling test – start and end.

Next, go to 'Trainee Selection', 'Trainee Information', 'Exercise Metrics' and select your discipline again. The button 'Define MFT test using test file' will appear. After you clicked the button another window opens. There you have to select the correct data file, what kind of test you did and you have to set the right periods of the test. Click the round calculate button. Your MFT results will be displayed in the result window. If you want to use the results as your new MFT values click 'use result as MFT'.
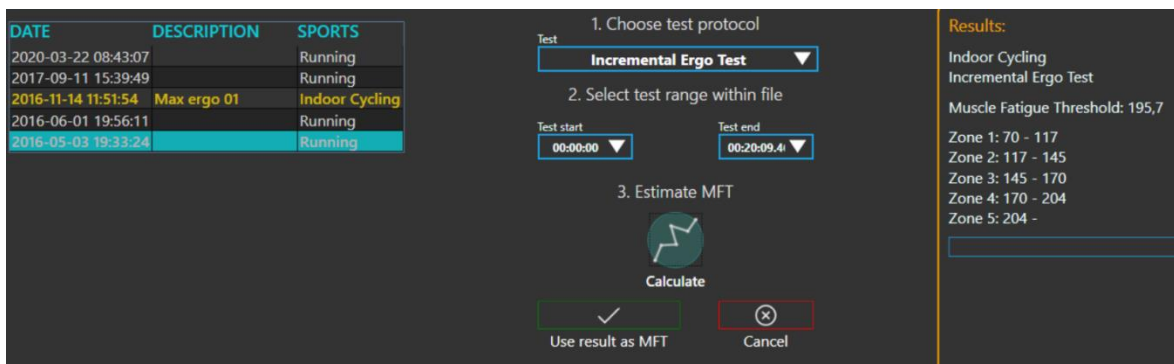
HOW TO USE THE FEATURE?
If you didn't set individual MFT values yet, default values will be used.

Online recording

For online recording, exercise type and target zone can be selected (see 'Online Measurement'). After the selection the discipline specific MFT values are loaded into setup.

When you start *Research view* recording, you can select 'Draw muscle load zones as overlay' from the overview settings. The MFT based training zones will be displayed in the overview window. When using the *Live view* interface the training zones will be shown in the section 'Zones' or can be displayed by using the plus button in the top left corner. See articles regarding the training zones on the Myontec website.

The individual thresholds will be shown for each muscle in *Research* and *Live view*.

Post Analysis

As explained before you can select 'Draw muscle load zones as overlay' from the overview settings after you opened the file. It is also possible to show the individual thresholds. Therefore open the signal settings and click on 'show thresholds if set'.

Peinabo A.B, Rojo J.J., Calderón J. & Maffulli N. 2014. Responses to increasing exercise upon reaching the anaerobic threshold and their control by the nervous system. BMC Sports Science, Medicine and Rehabilitation 6:17. http://biomedcentral.com/2052-1847/6/1/17

Tikkanen O., Hu M., Vilavuo T., Tolvanen P., Cheng S. & Finni T. 2012. Ventilatory threshold during incremental running can be estimated using EMG shorts. Physiological Measurements 33: 603-614.

Appendix 2   Muscle-specific thresholds

HOW TO SET MUSCLE-SPECIFIC THRESHOLDS?

At 'Trainee Selection', 'Trainee Information', 'Exercise Metrics' you can select to which discipline you want to add a threshold. After you select a discipline, the 'Add Thresholds' button appears and you can set individual thresholds for each muscle group.

HOW TO USE THE FEATURE?

The muscle-specific threshold is used to monitor individual muscle group separately, while the MFT is used for the total muscle load. For example, if your goal is to increase your hamstring activation, you can evaluate the muscle activation during exercise with the 'Trainer' feature and thresholds in *Live view*.
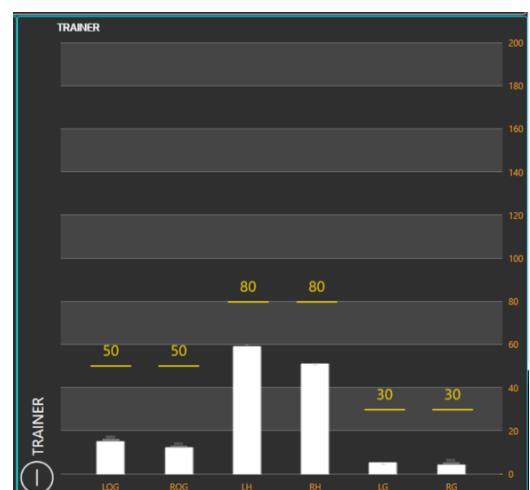
Appendix 3   Appending external data to an exercise file

If you have an existing measurement you wish to add some additional data, you can do so by creating a pre-defined .csv file.

-You must have existing Muscle Monitor measurement as target data

-First row is a header row with variable names

-Rows after that consist of the data

-Each column is separated with a separator (comma or semicolon)

-First column is always "time" in full seconds

-Use dots to separate digits in values

List of supported variables:

Time (s)

Heart Rate (bpm)

R-R Interval (ms)

Power (w)

Cadence (rpm)

Speed (km/h)

Distance (m)

Example file:

```
 1   Time;HeartRate;Power;Speed;Distance
 2   1;99;100;9;9
 3   2;99;120;9;18
 4   3;99;300;9;27
 5   4;99;300;9;36
 6   5;100;300;9;45
 7   6;101;300;9;54
 8   7;102;300;10;64
 9   8;102;300;10;74
10   9;102;300;5;79
11   10;102;300;5;84
12   11;104;300;5;89
13   12;104;300;5;94
14   13;105;300;7;101
15   14;105;300;7;108
16   15;107;300;7;115
17   16;108;300;7;122
18   17;107;300;7;129
19   18;107;300;7;136
20   19;107;300;5.751633987;141.751634
21   20;106;300;5.561747506;147.3133815
22   21;107;300;5.371861025;152.6852425
23   22;108;300;5.181974544;157.8672171
24   23;108;300;4.992088063;162.8593051
25   24;108;300;4.802201582;167.6615067
26   25;108;300;4.612315101;172.2738218
27   26;107;300;4.422428621;176.6962504
28   27;108;300;4.23254214;180.9287926
29   28;108;300;4.042655659;184.9714482
30   29;108;300;3.852769178;188.8242174
```

Considerations:

-Imported data does not extend the length of the file. Rest of the data is omitted.

-If a data exists with a given variable and time, the data is overwritten and previous data is lost!

E.g. If your file already contains HR and your custom data contains HR, the custom HR overwrites the previous data

Appendix 4   Checking Bluetooth Smart driver

If the MCell device cannot be found when adding new devices, check if the Bluetooth dongle driver is correctly installed:

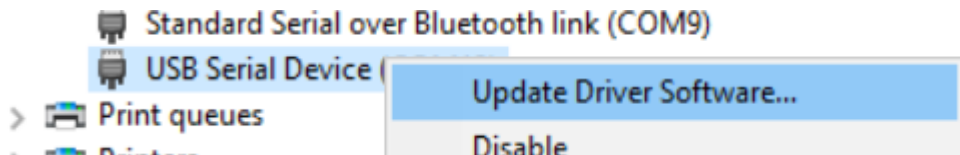1. Go to the Windows Device Manager.
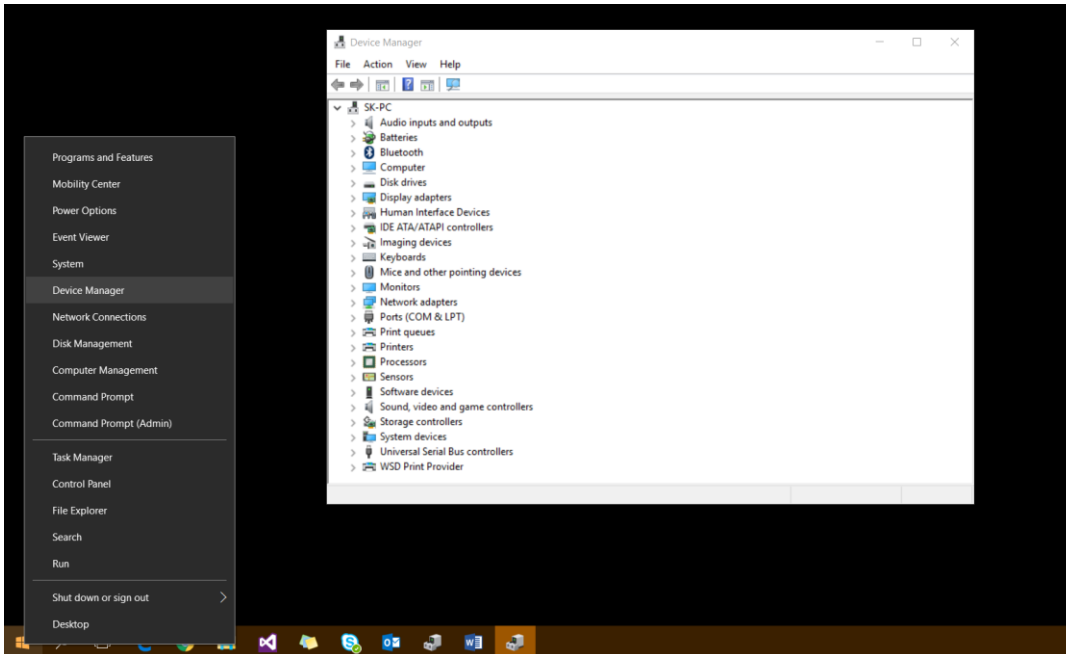
2. Plug in the BLED112 Bluetooth dongle. Check Under "Ports" that it recognizes dongle as "Bluegiga Bluetooth Low Energy". The Driver is correctly installed.
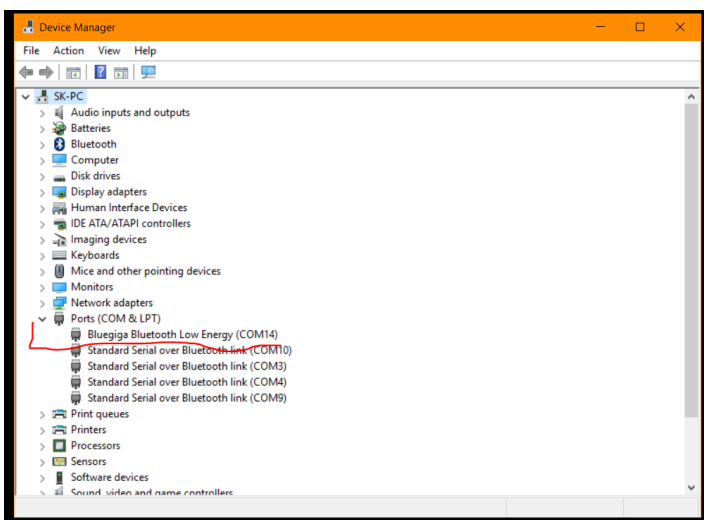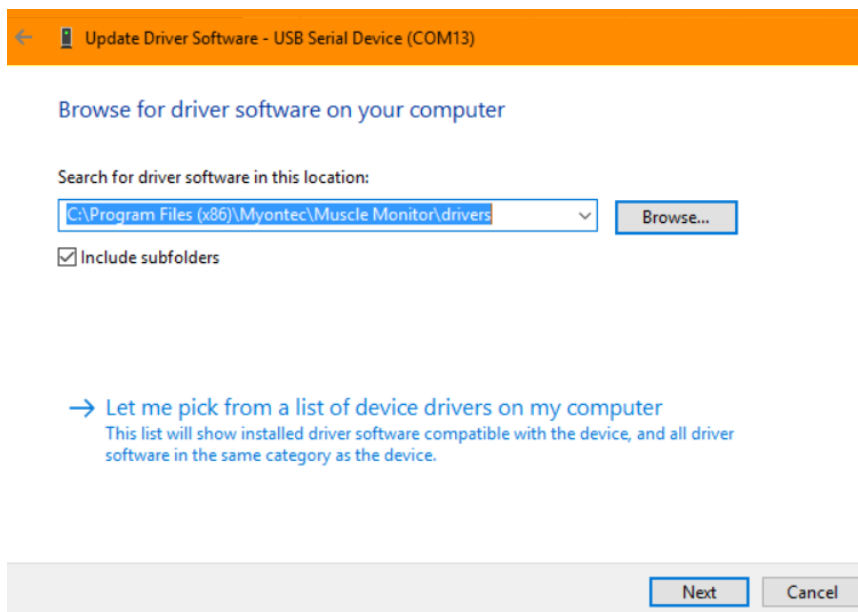
3. If the correct driver cannot be found and instead "USB Serial Device" or similar appears, Update the driver...

4. Right mouse click the device and select "Update Driver Software..."

5. Manually select the location where the Muscle Monitor was installed.

6. Click "Next" and look for device described in step 2.

7. If successful, Restart Muscle Monitor and attempt the search again.

Appendix 5   PDF record

myontec

Name: Sport Samples
Weight: 0kg
Heigth: 0cm

Indoor cycling, General MFT-test
Duration: 00:35:05
4 laps

Overview
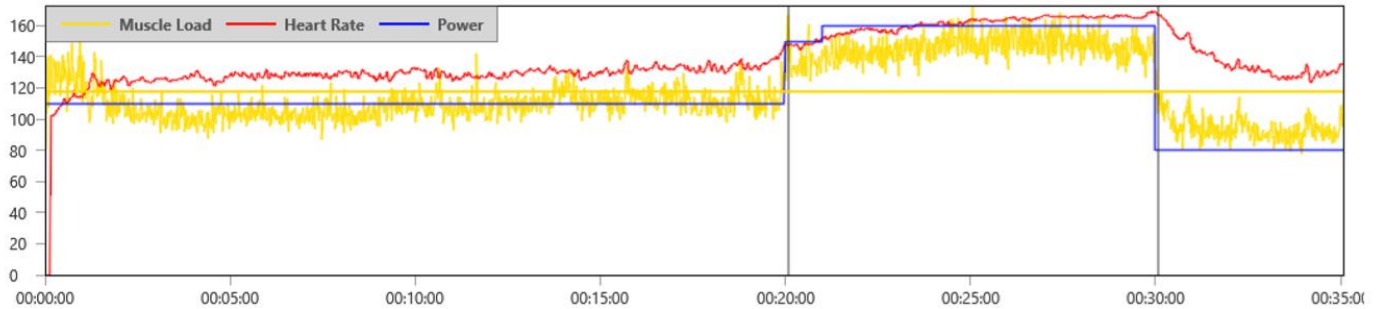
⏱	🫁 AVG	❤ AVG	⚡ AVG	↻ AVG	◐ ALL	⬤ Q|H	🏃 AVG	📏	🫁 TOT
00:35:05	117,7	139	120	76	48,8 | 51,2	56,1 | 43,9	-	-	247697

Notes

Lap 1 / warmup: 110 W, 110 MA/min, 75 rpm, 130 bpm
Lap 2 / effort: 160 W, 146 MA/min, 75 rpm, 160-180 bpm
Lap 3 / cooldown: 80 W, 94 MA/min, 75 rpm, 166-127 bpm

MFT-value: 149 MA/min

Distribution

Laps
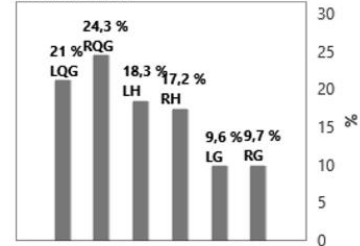
No.	⏱	🫁 AVG	❤ AVG	⚡ AVG	↻ AVG	◐ ALL	⬤ Q|H	◑ Q	◐ H	🏃 AVG	📏	⏱
Lap 1	00:20:05.32	113	128	110	76	49 | 51	58 | 42	46 | 54	53 | 47	-	0	00:00:00.00 - 00:20:05.32
Lap 2	00:09:58.24	149	161	158	77	49 | 51	55 | 46	48 | 52	50 | 50	-	0	00:20:05.32 - 00:30:03.56
Lap 3	00:05:01.60	97	137	80	72	47 | 53	54 | 46	44 | 56	51 | 49	-	0	00:30:03.56 - 00:35:05.16

Appendix 6   Variables

Name	Icon	Description
Muscle Load		Represents the momentary loading of the muscles; Sum of all recorded signals
Heart Rate		Recorded heart rate (bpm)
Power		Recorded Power (W)
Cadence		Calculated cadence. By default, this is estimated from the cyclic peaks from Muscle Load
Speed (Pace)		Recoded speed (km/h)
Distance		Recorded distance (m)
Ratio Quads / Hams		Relative signal strength of quadriceps versus hamstrings
Balance Left / Right		Relative signal strength of left side versus right side of recorded muscles.
Muscle Group Balance (with Problem detection)		Muscle balance within a specified muscle groups
Muscle Group Balance (Quads)	Quads	Muscle balance within a specified muscle group
Muscle Relax (with Problem detection)		Represents how well the muscle relaxes between work cycles. Increased values may indicate increased risk of injury

AVG - Average value of selected area

MED - Median from selected area

MAX - Highest single value from selected area

MIN - Lowest single value from selected area