sEMG Manual

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Background sEMG Information

Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an electromyograph to produce a record called an electromyogram. An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. A motor unit is composed of a motor neuron and all the muscle fibers that are innervated by that motor neuron. In a persistent muscle contraction, multiple motor units are firing repetitively throughout the contraction of the muscle. The strength of a muscle contraction is related to the number of motor units in the muscle that are activated during the same time period.

Surface EMG assesses muscle function by recording muscle activity from the surface above the muscle on the skin. Surface EMG can be recorded by a pair of electrodes or by a more complex array of multiple electrodes. More than one electrode is needed because EMG recordings display the potential difference (voltage difference) between two separate electrodes. The electromyogram (EMG) recorded during the muscle contraction is seen as a burst of spike-like signals, and the duration of the burst is about equal to the duration of the muscle contraction.

sEMG Manual

Hardware

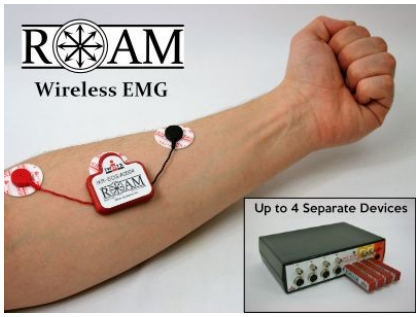
The SEMG signal generated by the muscle fibers is captured by the electrodes then amplified and recorded with an iWorx recorder. It is then sent to the computer to be processed, displayed and recorded by the LabScribe software.

Hardware set up will vary depending on which iWorx recorder you are using. iWorx provides solutions for wireless recording (the ROAM EMG recorder), wired recording (the RS-EMG series) as well as expandable systems. Each recorder has directions that will pull up when the Settings is loaded.

Wireless Systems:

ROAM Wireless USB system:

- ROAM Wireless EMG (1 Channel) – IXR-B1
  - with Accelerometer – IXR-B1A
- ROAM Wireless EMG (2 Channels) – IXR-B2
  - with Accelerometer – IXR-B2A



ROAM Wireless Expandable system(RS-WEMGx):

The IX-RA-834 versatile data recorder can be used with multiple iWire-B2 (or iWire-B2A) wireless EMG modules to record upto 8 channels of wireless EMG

Wired Systems:

Recorders and Amplifiers that can be used for recording EMG include:

RS-EMGx EMG System

Based on the IX-Bxx series, such as IX-BIO4, IX-BIO8, 4 channel or 8 channel USB powered recorders.

Expandable EMG system

Based on the IX-RA-834 or the IX-TA-220
Add the iWire-B3G, iWire-BIO4, iWire-BIO8 modules to the IX-TA-220 or the IX-RA-834 recorders to record upto 20 EMG channels, as well as other physiological parameters. The IX-TA-220 includes a High voltage, constant current stimulator, safe for use on Humans.

Amplifiers:

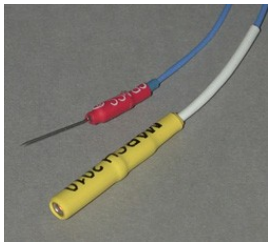
In addition to the above complete systems, the following iWorx sensors and amplifiers can be used with any recorder:

- C-ISO-256 used with the IA-400D or the ETH-256 Amplifier
- IA-100B

Consumables

The silver-silver chloride electrodes are the part of the instrument that is in contact with the skin by making electrical contact between the skin and the sensor. Silver-silver chloride electrodes are the best electrodes for recording EMG signals. The electrodes are disposable and should be replaced after each use.

iWorx offers three types of silver-silver chloride electrodes differing based on the width of the adhesive material and position of the electrode in it.

Picture	Description (click part number to go to website)
	A-GC-7165 Foam solid gel electrodes 50 x 54mm 150 per package
	A-GC-7165P Pediatric foam solid gel electrodes 30mm 150 per package
	A-ELEC-E-30 Foam solid gel electrodes 35 / 53mm Latex and PVC free Diaphoretic / Hypoallergenic
	C-ISO-GNE5 Platinum Subdermal Needle Electrode (48 inches) 10mm length, 30-gage Set of five *for animal use

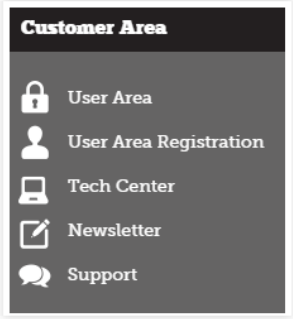
Proper skin preparation is important to get a good signal and avoid artifacts.

- Before applying electrodes, make sure the skin surface is clean and dry:
- Abrade the skin with an abrasive cream, such as NuPrep, to remove dead skin.
- Alternatively, you can also clean skin with an alcohol wipe and let it dry, but this is not as efficient as the abrasive cream.

Tips:
It is easier to connect the electrodes to the snap cable before placing the electrode on the subject.

Registration and Software Installation

Downloading Software



1. The equipment comes with a Temporary User Name and Password, so that you can immediately get started with your system by downloading and installing the software. It is strongly encouraged that you register as a User on the iworx.com website with your own UN and PW.
2. Go to iworx.com - then click the "User Area Registration" link from the customer area of the main page (grey box half way down the page on the right hand side).
3. Complete the registration form making sure to enter information in all the required fields.
4. You will receive an email from iWorx when your registration is complete, which may take upto 24 hours. Until then use the temporary username and password
5. Log on as an iWorx user on the website and download LabScribe Software.
   a. Go to www.iworx.com - then click the "Software" tab from the top menu selections.
   b. Click "Downloads" and enter your username and password.
   c. Click "Research".

   d. Select the correct "Complete Installer" for your operating system.
   e. Follow the directions for saving to your hard drive. **Double-click** for saving directly to your computer; **right-click** to save to another location.
   f. For Mac Users, download the "Package" and follow the prompts to install.

**You need Administrative Access to your lab computers to install the software to the lab

computers. If you do not have Administrative Access, please contact your IT department.

Note for IT Depts. doing the installation: Users must be able to save to the local drive. They will need permissions to write to C:\Users\USERNAME\AppData\Local\LabScribe

Loading Setting Group

1. Once installed you should see a LabScribe shortcut on your desktop.
2. Click the shortcut and open LabScribe.
3. Load Settings Group if necessary (you only have to do this the first time you start LabScribe)
4. Click Settings → Load Group
5. Choose **Research Settings** → Choose your equipment from the list.
6. Choose the group you wish to load. And click “Open”
7. The window will close and you will be back to the original LabScribe recording window

Choosing the Settings

1. On the LabScribe Recording window – Click "Settings"
2. You should now see a list of Experiments. They may be in folders.
3. When you click on any lab exercise two windows will open –
   1) a PDF of the lab exercise setup for that experiment
   2) a LabScribe recording window with the settings needed to run the experiment

Learning to use Labscribe

Various tutorial videos for using LabScribe are available on the iworx website,

at https://www.iworx.com/tutorials

EMG Recording and Analysis

1. Instruct the subject about the procedure he or she will be doing during the exercise
2. Start Recording in LabScribe (tutorial video here - Recording with LabScribe)
3. Have the subject perform the exercise.
4. Marks can be made in the record either during or after recording. Marks can be preset as well (tutorial video here - Making Marks in LabScribe).
5. A listing of all the marks made during recording can be brought up by pushing the "Marks" button (tutorial video here - Locating Marks in LabScribe)
6. Click Stop to halt the recording.
7. Click AutoScale on all channels to show the complete EMG activity.
8. Learn how to do basic measurements in LabScribe (maximum amplitude, minimum, derivatives) by either referring to the LabScribe Manual or through the following video tutorial (Basic Measurements in LabScribe).
9. A listing of other LabScribe tutorial videos can be found here - https://www.iworx.com/tutorials

LabScribe has various built-in analysis protocols to simplify EMG analysis.

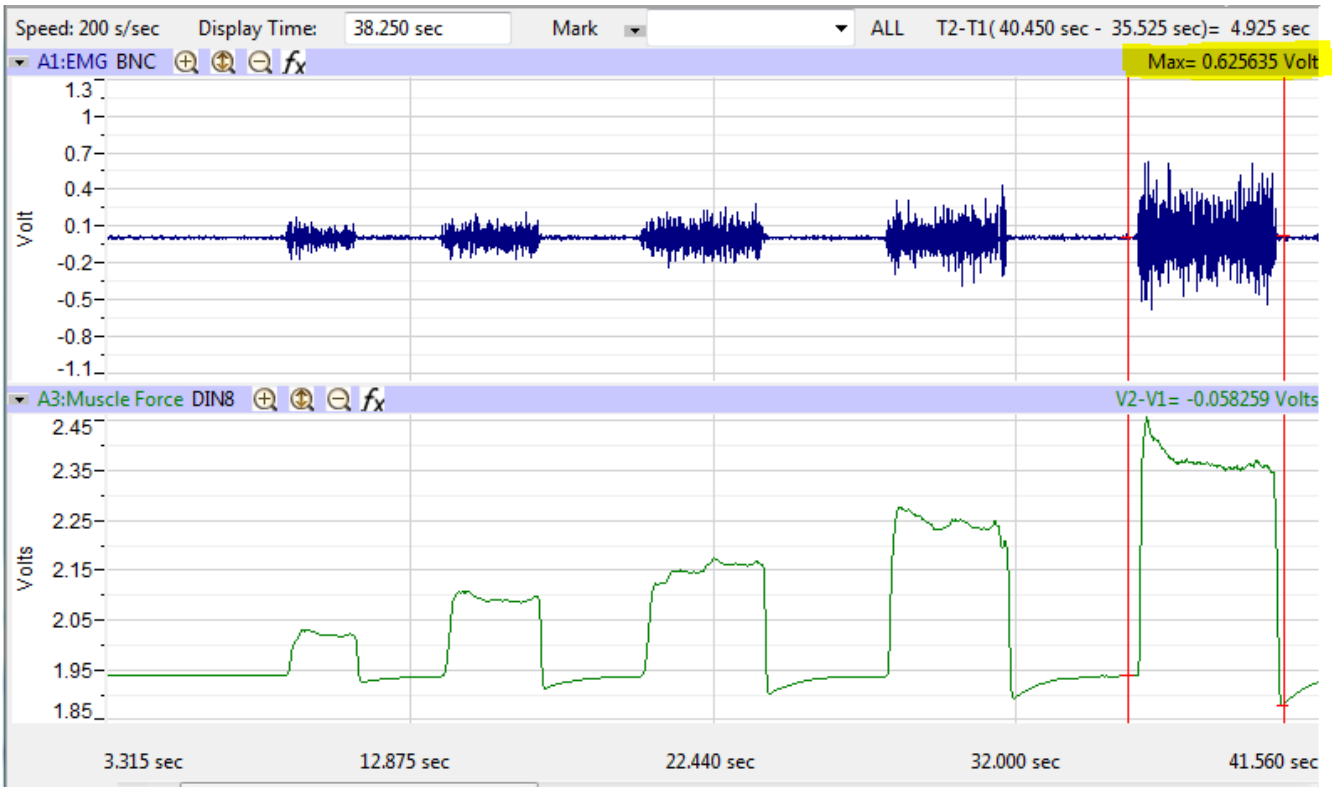
Normalizing to Maximal Voluntary Contraction (MVC)

1) Acquire the EMG data on a subject performing MVC.

2) Set the Channel Function to Max, at the right hand top of the Channel Bar.

3) Place the 2 cursors around EMG signal you want to normalize.

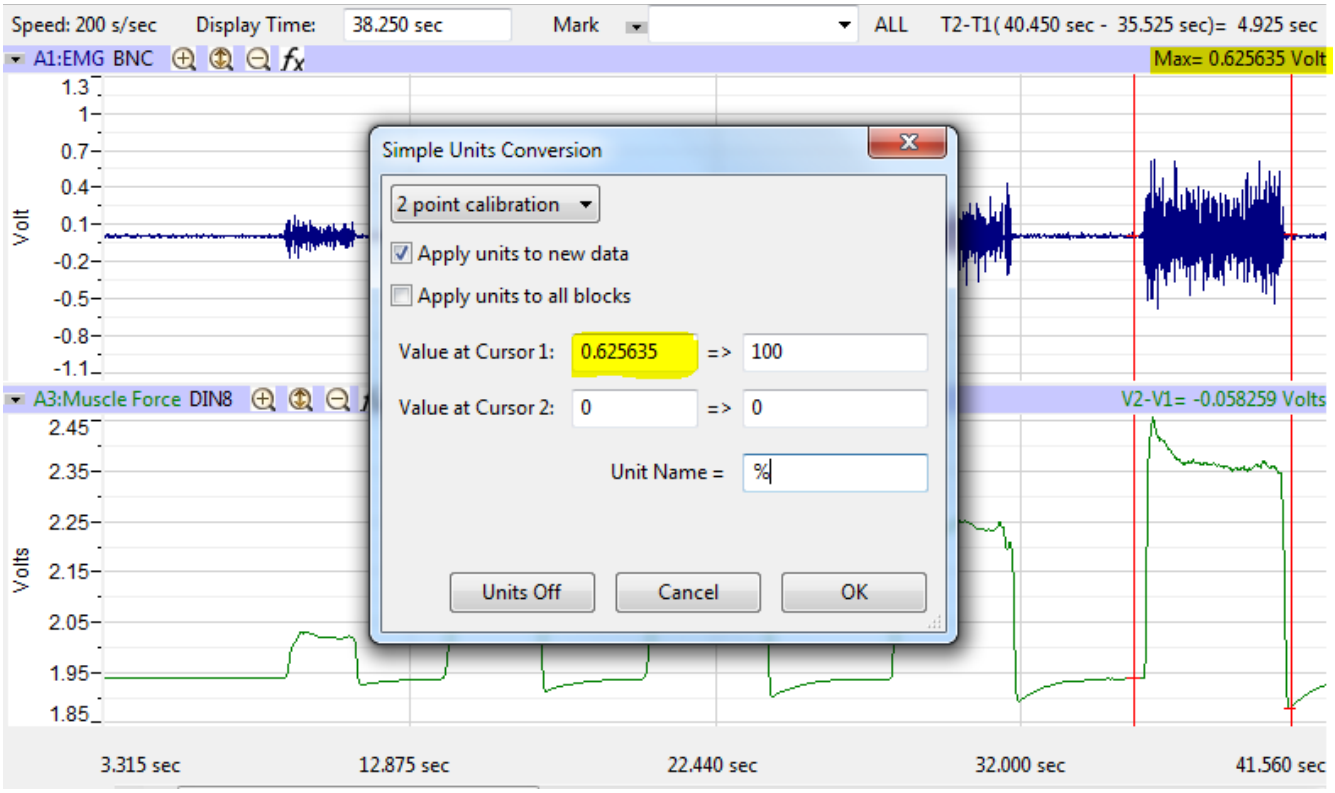
4) Read the max value between the cursors, in Volts. (If you have already done units conversion, you need to turn off the units for the channel first).



5) Right-Click in the channel, go to Units→Simple.

Set Value at cursor1: Max Value from Channel Bar => 100
Set Value at cursor2: 0 => 0
Set Units to %

Choose if you want to apply the units to all blocks or only this block. A Block is defined as start and stop of recording. To apply this MVC to all recording from the subject, in this file, Choose “apply the units to all blocks”.

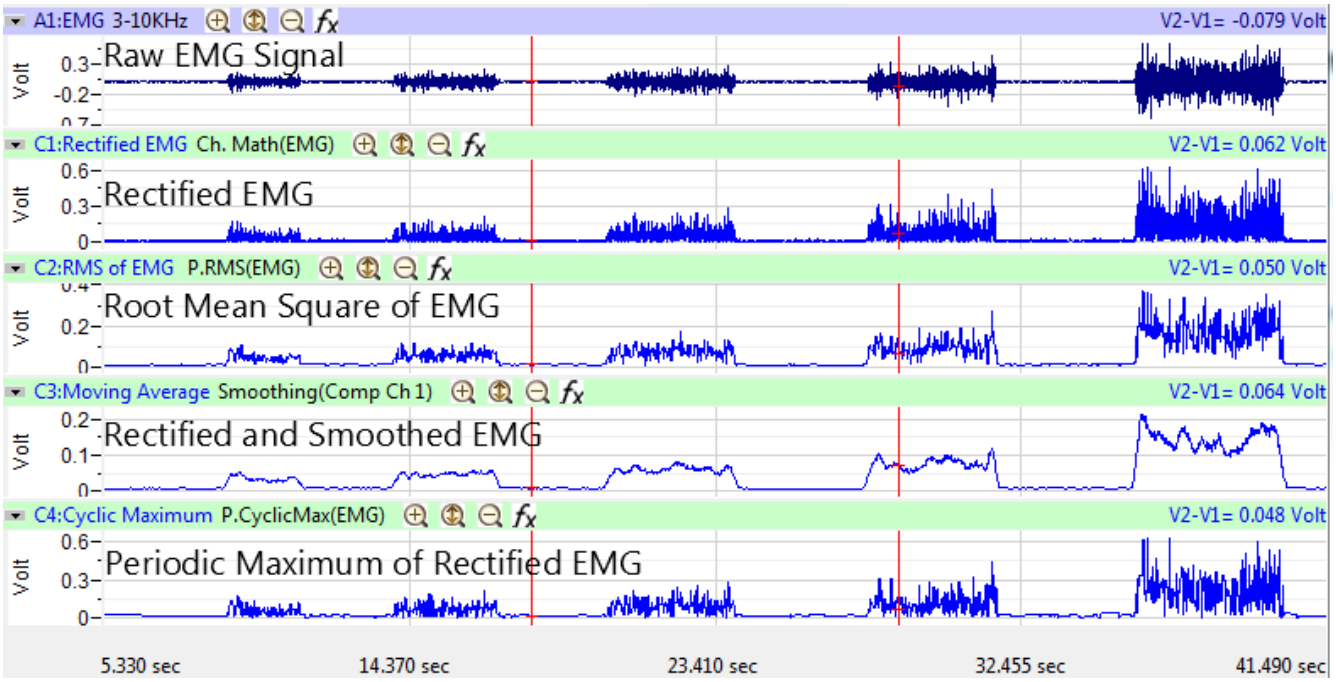


Click OK.

The EMG channel is now Calibrated in %MVC.

Time Domain Analysis:

Time Domain Analysis uses computed functions. Learn more about how to create computed function by referring to the LabScribe Manual or view the video at Computed Functions in LabScribe.



Rectified EMG Data:

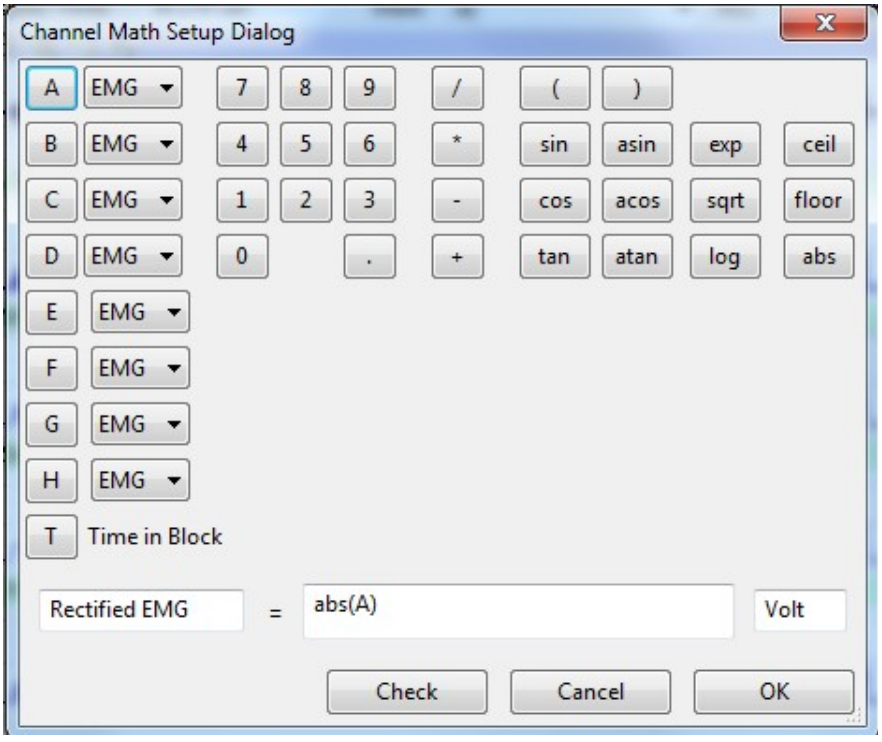
To rectify a channel:

1. Click on the channel's "Add Function" button,

2. Choose Channel Math.

3. Choose the Channel to be rectified, as the A channel.

4. Type in abs(A) in the function text area. Then click OK.



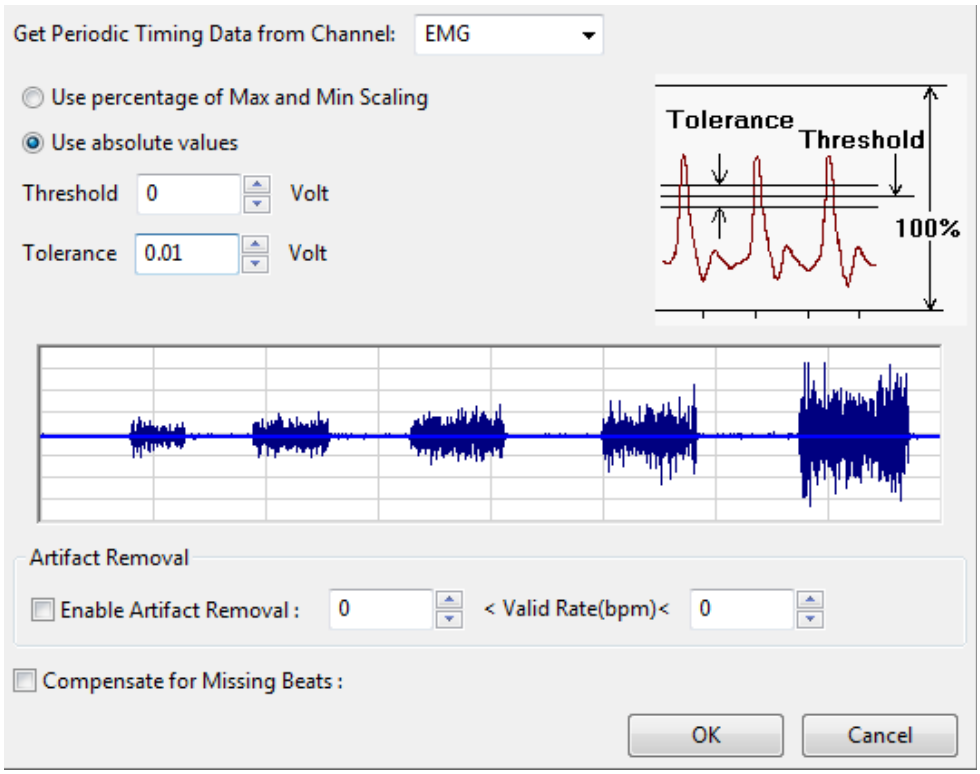
RMS (Root Mean Square):

To calculate the RMS of a channel:

1. Click on the channel's "Add Function" button, f_x.
2. Choose Periodic
3. Coose RMS.
4. Set the Threshold and Tolerance.

Since EMG data is AC coupled, we can use Absolute values for the threshold and tolerance. Also we can set the Threshold at Zero.

The raw EMG data values are squared and then the square root is calculated.



Envelope EMG Data:

There are 2 options to calculate the Envelope of the EMG signal:

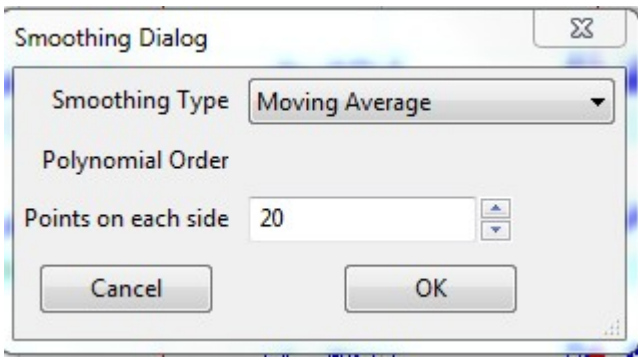
1) Smoothing the Rectified Data

2) Calculating the Periodic (cyclic) maximum for each cycle of the EMG

Smoothing the Rectified Data:

To Smooth the rectified EMG signal:

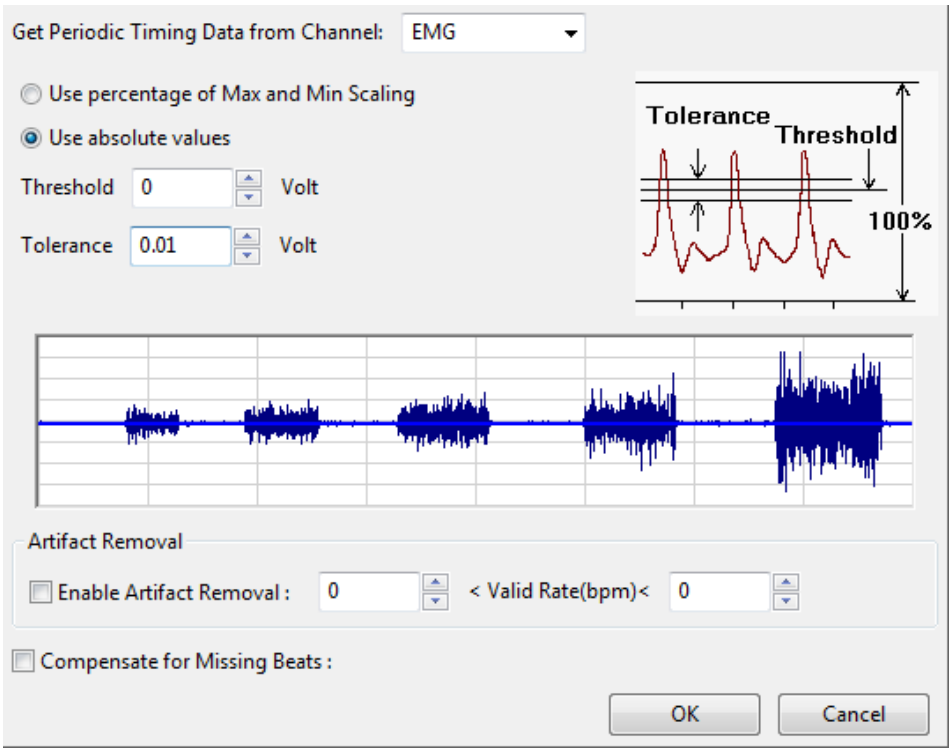
1. Click on the Add Function button f_x of the Rectified EMG channel
2. Choose Smoothing
3. Choose the smoothing type: Moving Average
4. Choose the number of points for the moving average



Cyclic Maximum of EMG:

To Smooth the Rectified EMG signal:

1. Click on the EMG channel's Add Function button, fx
2. Choose Periodic, then Cyclic Maximum
3. Set the Threshold and Tolerance as in the RMS setup.

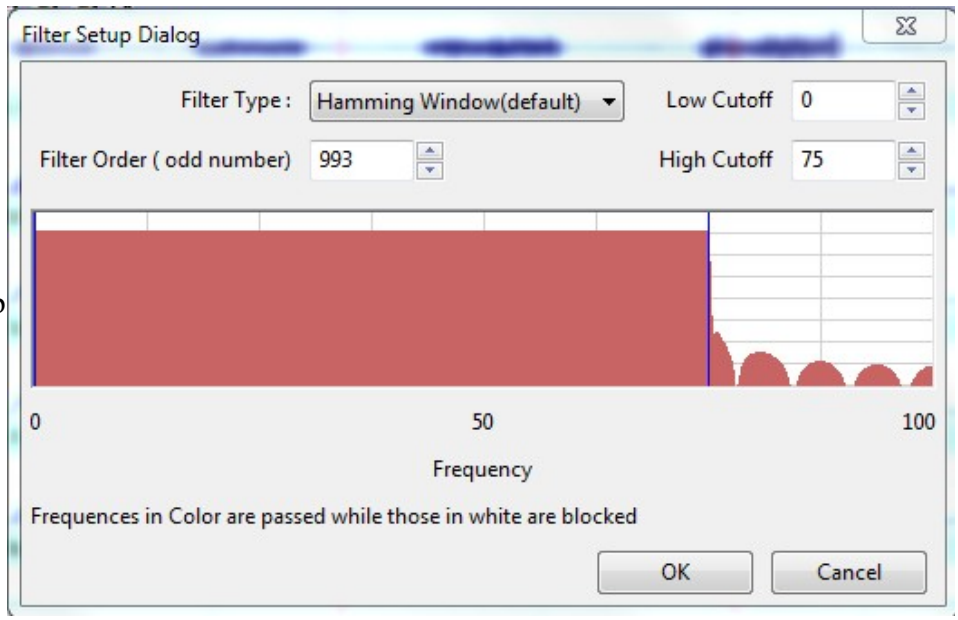


Filtering:

A User Defined Filter can also be applied to the Rectified EMG signal.

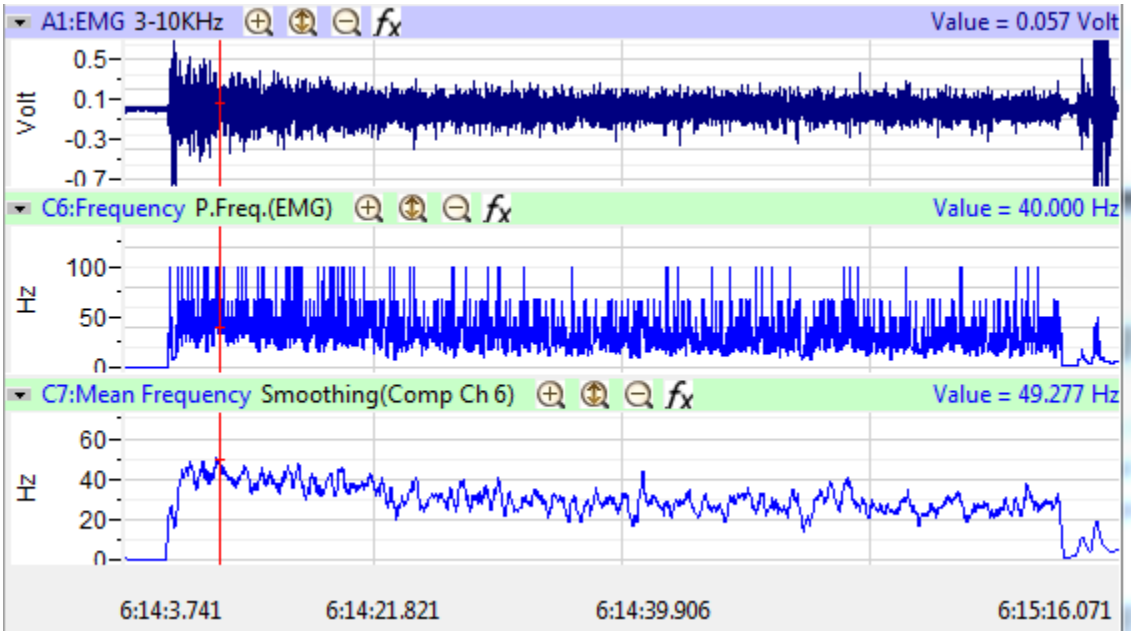
To Filter the Rectified EMG signal:

1. Click on the EMG channel's Add Function button, fx.
2. Choose Filter
3. Choose FIR Filter
4. Set the type of filter (from drop down menu) and filter cutoffs
5. Choose Filter Order



Mean Frequency:

Mean Frequency of the EMG signal decreases with time during the task that induces Fatigue.



To calculate the Mean Frequency, first calculate the Frequency of the EMG signal.

1. Click on the EMG channel's Add Function button, f_x.
2. Choose Periodic, then Frequency.
    - The Periodic frequency dialog setup is similar to the RMS setup.
3. Click on the Periodic Frequency channel's Add Function button, f_x.
4. Choose Smoothing and set up the smoothing channel.

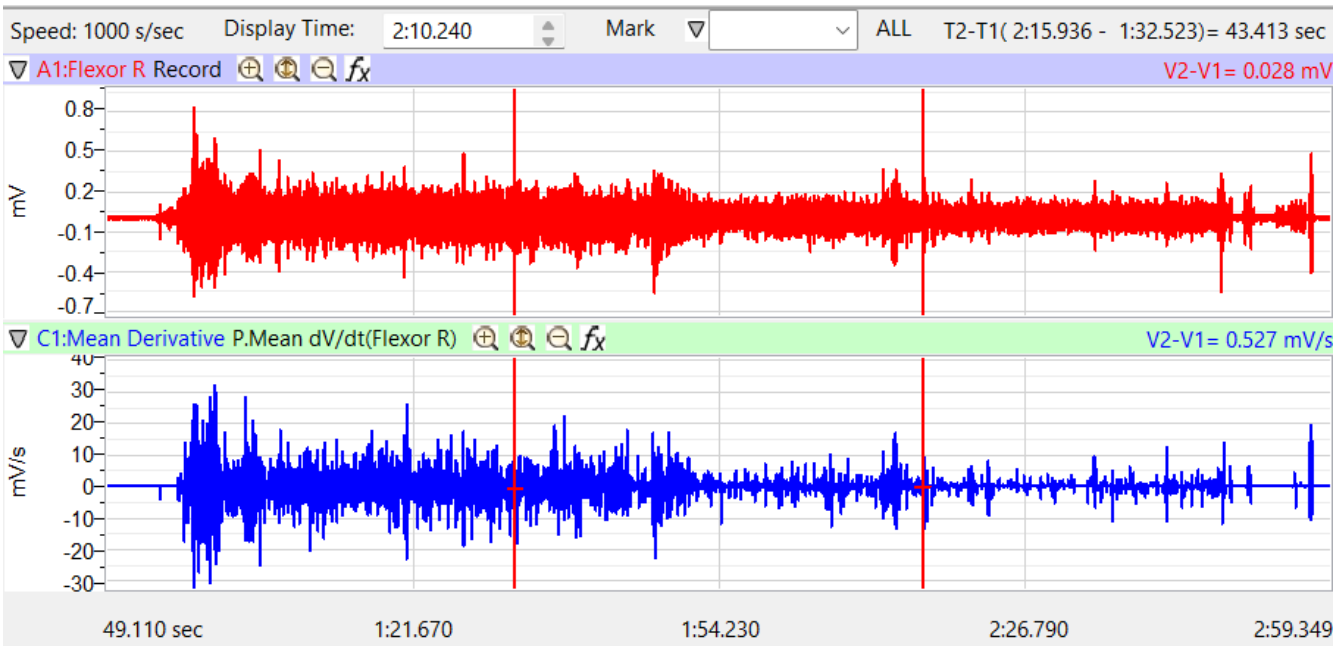
We now have a channel that is the mean Frequency of the EMG signal.

Mean Derivative:

Mean Derivative of the EMG signal decreases with time during the task that induces Fatigue.

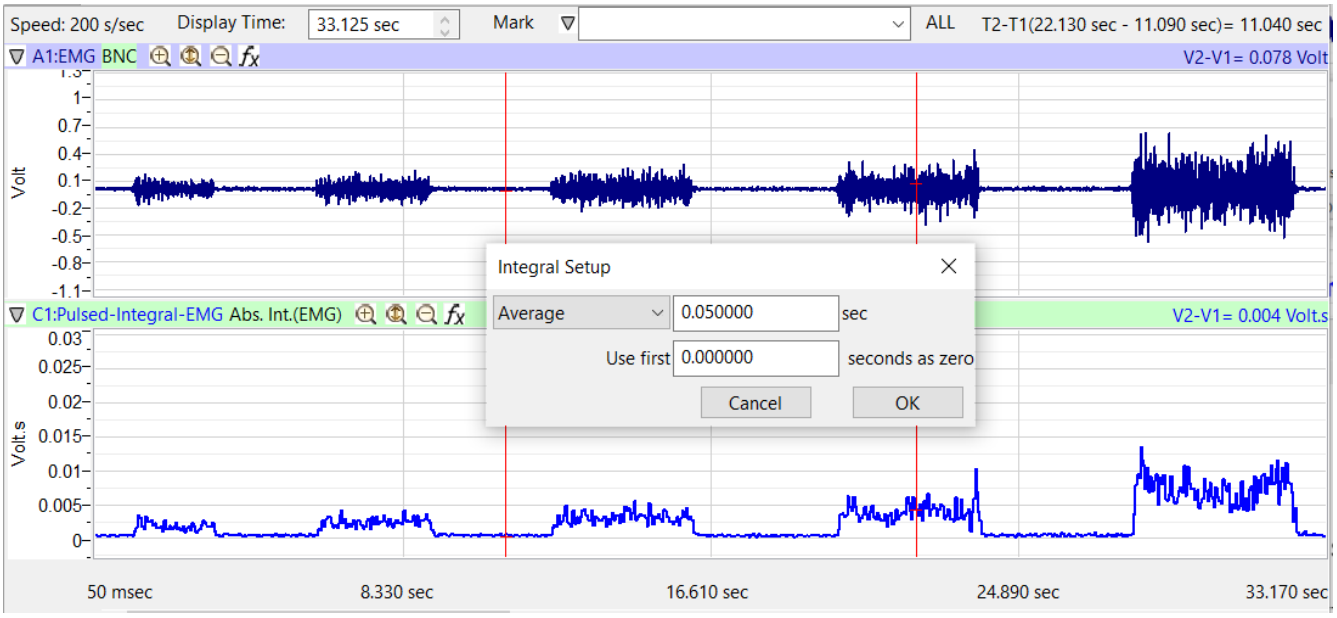
To calculate the Mean Derivative.

1. Click on the EMG channel's Add Function button, f_x.
2. Choose Periodic, then Mean dV/dt.
    - The dialog setup is similar to the RMS setup.



Pulsed Integrator:

Use Absolute Integral and averaging to pulsed integration circuit which provides a voltage proportional to the area under the rectified EMG curve in discrete time windows.



1. Click on the EMG channel's Add Function button,

2. Choose Integral, then Absolute.

The Integral dialog setup Choose Average and the time typically 0.05 sec.

We now have a channel that is the Pulsed integral of the EMG signal.

Bak, M. and G. Loeb. “A pulsed integrator for EMG analysis.” *Electroencephalography and clinical neurophysiology* 47 6 (1979): 738-41 .

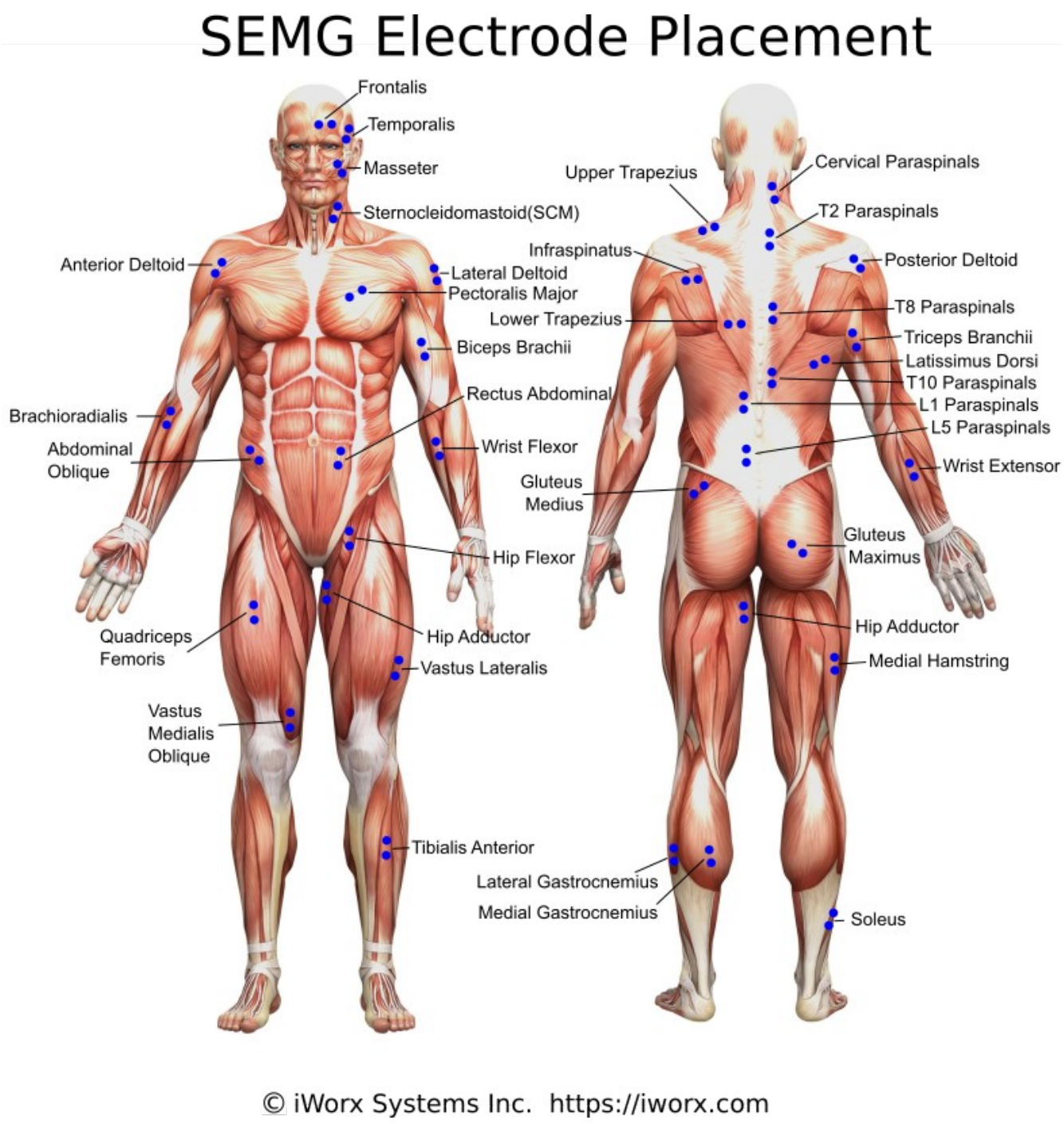
Muscle Groups and Electrode Placement

Major Muscle Group	Location	Functional Role	Exercise to Strengthen	Sample Stretch	Notes
Abdominal	Stomach	Sitting up, postural alignment	Crunches, leg raises, twisting crunches	You typically don't stretch your abs. For most people, the abs are not strong enough, so you need to work on strengthening them rather than stretching them	The rectus abdominus is the muscle that is visible. The transversus abdominus muscle, which stabilizes your back, is underneath.
Biceps	Front of upper arm	Lifting, pulling	Bicep Curls	Sit on floor. Place hands behind you with fingers pointing away from your body. Walk your hips away from your hands.	Anytime you move your hand toward your shoulder, you are using your biceps.
Deltoids	Top of shoulder	Overhead lifting	Pushups, bench press, side & rear arm raises	"Scratch your Back" - Put both hands over your head. Bend one elbow and place hand on back. With other hand, push elbow to stretch triceps, deltoids, lats	The deltoids are composed of three parts, anterior, posterior & medial. Anytime you "flap" your arms, your deltoids are working.
Erector Spinae	Low back	Postural alignment	Back extensions	"Cat Stretch" - Kneel on all fours, round back like a cat. Sit on chair with feet shoulder distance apart. Bend over and place shoulders between your knees	The erector spinae is sometimes called the "low back" muscle, although it runs up your entire back.
Gastrocnemius & Soleus	Back of lower leg	Push off for walking, standing on tiptoes	Standing calf raises, seated calf raises	Lunges with a straight back leg for gastrocnemius. Lunges with bent knees for soleus.	The gastrocnemius gives your legs a rounded shape. The soleus is underneath the gastrocnemius.
Gluteus	Buttocks	Climbing stairs, walking, standing up	Squat, leg press	Sit on chair, cross other leg over thigh of bent leg, lean forwards.	Made up of several muscles. The largest muscle in the body is the gluteus maximus.
Hamstrings	Thigh - back	Walking	Squats, lunges, leg extensions, leg curls	While standing, place heel of leg to be stretched on a chair. Keep your leg as straight as possible, your hips square and your back flat. Bend at the waist toward your leg.	The hamstrings are made up of three muscles. Don't squat below 90 degrees, otherwise you could damage your knees.

Latissimus Dorsi & Rhomboids	Back - Lats are the large triangular muscle in the midback. Rhomboids are between the shoulder blades	Postural alignment, pulling open a door	Lats - pull ups, chin ups, lat pull downs Rhomboids - chinups & bent arm rows	"Scratch your Back" - Put both hands over your head. Bend one elbow and place hand on back. With other hand, To stretch rhomboids, "hug yourself" Cross your hands in front of you, place both hands on your shoulder blades.	Developed lats give your back a "V" shape, making your waist appear smaller.
Obliques	Side of body	Rotation and side flexion of body	Twisting crunches, rotary torso	Lie on your back with your arms extended out ("T" shape) Bend both knees. Rotate your hips and put your bent legs on the floor on your side.	Strong internal and external oblique muscles ward off back pain.
Pectoralis	Front of upper chest	Push up from lying position, push open a door	push-up, pull-up, bench press	While standing, hold both arms out at shoulder height, palms forward. Pull arms back.	The pectoralis muscles pull the shoulder and arm forward.
Quadriceps	Thigh - front	Climbing stairs, walking, standing up	Squats, lunges, leg presses	While lying on side, grasp ankle, push hips forward	The quads are made up of four muscles.
Trapezius	Large muscle in upper and mid-back.	Moves head sideways,	upright rows, shoulder shrugs	Upper trap stretch. Sit in a chair; put your left hand behind you. Tilt your head so your right ear moves toward your right shoulder. Repeat on the other side.	Your upper trapezius connects your head to your shoulders. When you feel "knots in your neck", it's your trapezius.
Triceps	Back of upper arm	Pushing	Pushups, tricep extensions, dips	"Scratch your Back" - Put both hands over your head. Bend one elbow and place hand on back. With other hand, push elbow to stretch triceps, deltoids, lats	Anytime you extend your lower arm, you are using your triceps

Electrode Placement

- For electrode placement, put a single pair of electrodes on the blue dots as shown on the image below for the muscle activity you want to measure.



Sample Exercises

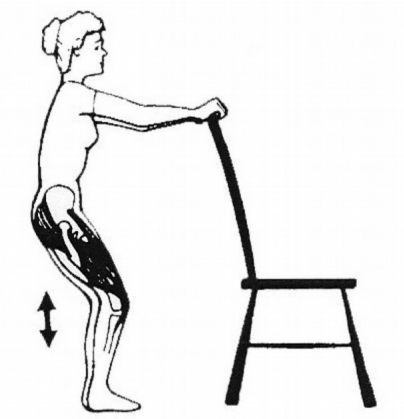
Note: These exercises should be performed only by individuals in good health, with no lower back, knee, or hip injuries.

Exercises should be performed using correct body positioning as shown and explained.

Core muscle engagement is critical when doing all of these exercises.

Squat

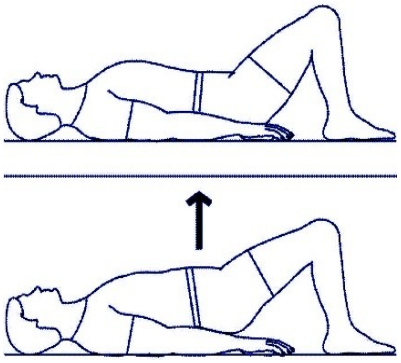
Targeted Muscle = Rectus femoris



- Stand with your head facing forward and your chest held up and out.
- Place your feet shoulder-width apart. Extend your hands and lightly grasp the top of a chair for balance.
- Sit back and down, like you are "sitting". Keep you head forward and let your lower back arch slightly as you "sit".
- Allow yourself to lower until your thighs are parallel to the floor, knees over ankles, weight into your heels.
- Keep your core tight and push through your heels to return to the starting position.

Bilateral Bridge

Targeted Muscle = Gluteus medius & Gluteus maximus



- Lay on your back with your hands by your sides, your knees bent and feet flat on the floor.
- Feet and knees should be approximately shoulder width apart.
- Tighten your abdominal and buttock muscles.
- Raise your hips up to create a straight line from your knees to shoulders.

Forward Lunge

Targeted Muscle = Rectus Femoris

- Stand with your feet hip-width apart, hands on hips (if you prefer).
- Keep your chest lifted and back straight, take a large step forward (about three feet) with the foot so the knee is bent 90 degrees and the thigh is parallel to the floor.
- Keep your knee centered over your foot. Push off the foot to return to the starting position.

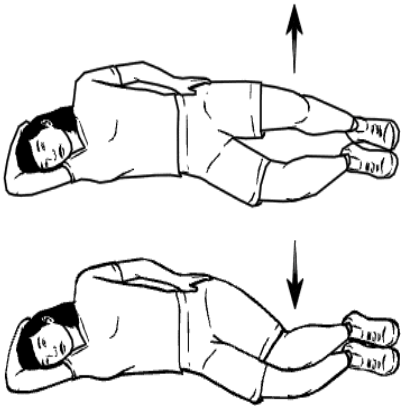
Standing Leg Abduction

Targeted Muscle = Gluteus Medius

- Hold on to a chair back to help balance.
- Keeping toes pointed forward, foot flexed, and leg straight, lift the foot off the ground and out to the side.
- Lower the leg without letting the foot or leg rest to complete one repetition.

Clam

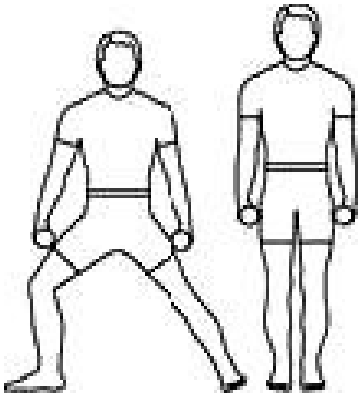
Targeted Muscle = Gluteus medius



- While lying on your side, keep both knees bent and flex the hips to about 30 degrees.
- While keeping your heels touching and pelvis still, open your knees by contracting your glute medius. This is a slow, small and targeted movement.
- You can place your hand on your gluteus medius (just below and behind your hip) to ensure that it is firing during the movement.

Side-Step

Targeted Muscle = Gluteus medius/Vastus muscles



- Place your feet front and shoulder width apart
- Keep your feet in line with your shoulders, and face forward with your body weight evenly distributed over both feet.
- Shift your weight over one leg and take a step laterally (sideways) with the other leg.
- Keep your hips level during the movement. Try not to bounce up and down or sway side to side.
- Slowly shift your weight to the moved leg and bring the other leg inward to a new ready position and repeat.

Forward Step-Up

Targeted Muscle = Rectus Femoris, Vastus muscles

- Begin by standing in front of a 4” aerobic step, facing forward.
- Place one foot in the middle of the step.
- Step up as you balance your body for 4 seconds.
- Step down and repeat

Sit-Ups

Targeted Muscle = Rectus Abdominus

- Begin by doing a pelvic tilt to flatten the back against the mat.
- Cross hands over the chest and stretch the legs out straight.
- Slowly "curl up" body towards toes until sitting.
- With control, slowly return body to the mat.

Bent-knee Curl-Up

Targeted Muscle = Rectus Abdominus

- Follow the above, but bend the knees and keep feet flat on floor.
- Raise your upper body off the mat until your shoulders are around 30 degrees off the mat.
- With control, slowly return to lie back on the mat.