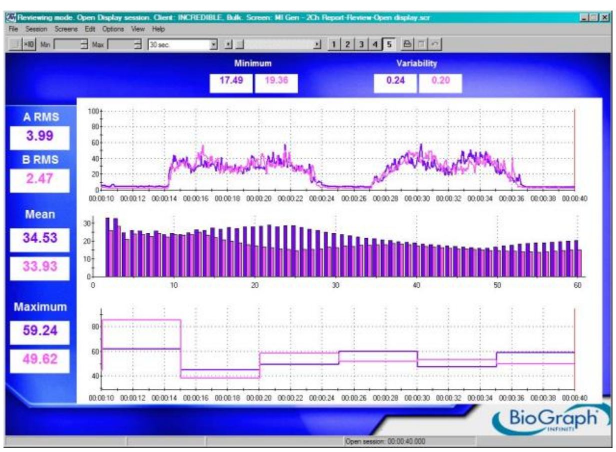
MyoTrac3 Clinical Guide



Thought Technology Ltd.

5250 Ferrier, Suite 812, Montréal, Québec H4P 1L3 Canada
Tel: +1 (800) 361-3651 • +1 (514) 489-8251 Fax: +1 (514) 489-8255
E-mail: mail@thoughttechnology.com
Webpage: http://www.thoughttechnology.com

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Table of Contents

Introduction

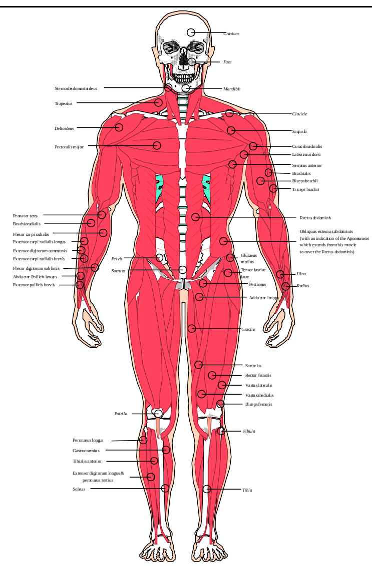
This clinical guide gives a general overview of the Surface Electromyography (SEMG). It presents the general concepts, gives general recommendations and suggests electrode placements.

This guide was written to assist you in the use of your system and in your general practice. It is not intended to replace scientific and clinical literature (a bibliography of reference books is available at the end of this guide).

After you have become familiar with the key concepts, you can use the rest of this guide as a reference and also as a source of information.

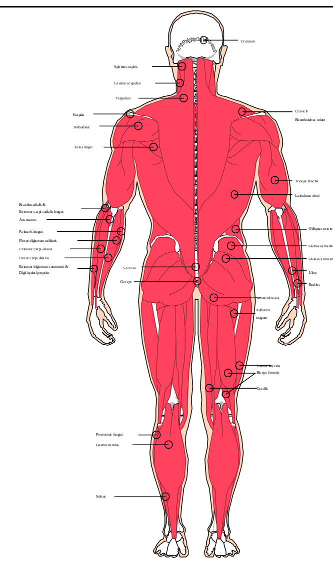
Muscle Cartography

The two next pages are anatomy boards. Prior to placing the electrodes, it is usually recommended to locate the muscle by palpation. These boards will assist you in this task. We recommend printing the two next sheets.



MUSCLES, SUPERFICIAL LAYER, ANTERIOR VIEW

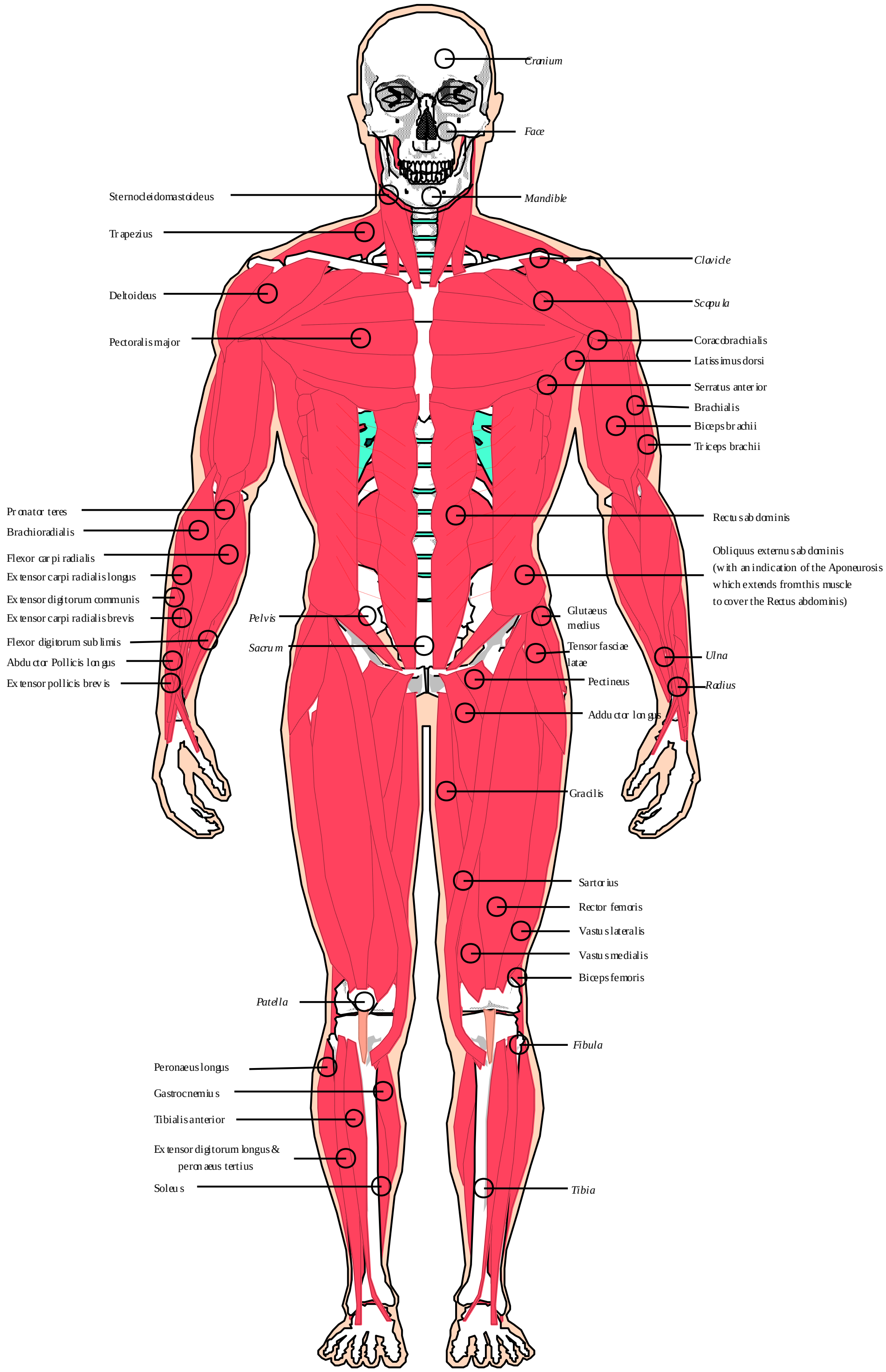
Anterior View



MUSCLES, SUPERFICIAL LAYER, POSTERIOR VIEW

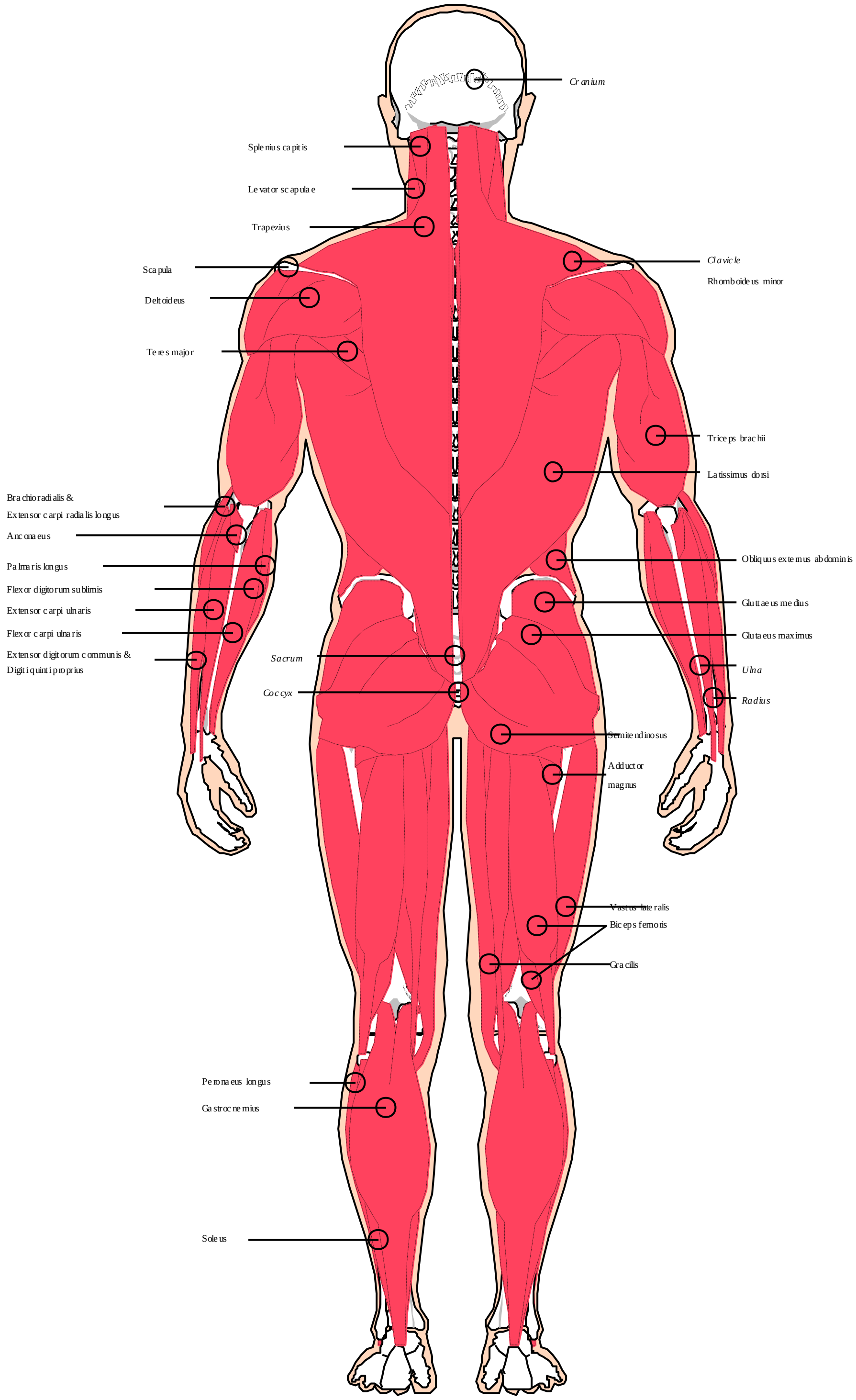
Posterior View

Anterior View (Superficial Layer)



MUSCLES, SUPERFICIAL LAYER, ANTERIOR VIEW

Posterior View (Superficial Layer)



MUSCLES, SUPERFICIAL LAYER, POSTERIOR VIEW

SEMG Basics

Definition

Surface **E**lectro**M**yo**G**raphy (SEMG) is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles.

Benefits

SEMG biofeedback involves measuring the subject's muscle tension and conveying such information to them in real-time in order to raise their awareness and conscious control of the related movement. It accelerates both the therapist's instruction to the patient, and the patient's ability to complete specific movements. Its role in controlling urinary and fecal incontinence is widely recognized and well-established.

By providing the user, and their therapist, access to muscular information about which they are both generally unaware, SEMG biofeedback provides accurate, reliable, measurable, objective data to augment and support the subjective reporting of the patient and observations of the therapist.

The microvolt (millionths of a volt) measurement values of muscle activity can be recorded and used to provide instant feedback for motivation, learning and improved rehabilitation, as well as trend reports over sessions over time to demonstrate with objective numbers the value of the therapy both to the patient and to the service provider or payer.

Indications

- Biofeedback
- Relaxation
- Muscle re-education
- Treatment of incontinence

SEMG is also widely used in sports (biomechanics, sports medicine and training, motion analysis), in ergonomics (studies in the workplace, job risk analysis, product design and certification), and in medical research.

Ways of looking at the SEMG signal

Different signal processing methods provide different ways to look at an SEMG signal.

Raw SEMG is an unprocessed SEMG signal, which consists of a collection of positive and negative electrical signals. Their frequency (how often they occur), and their amplitude give information on the contraction or rest state of the muscle. Figure 1 shows a raw SEMG signal.

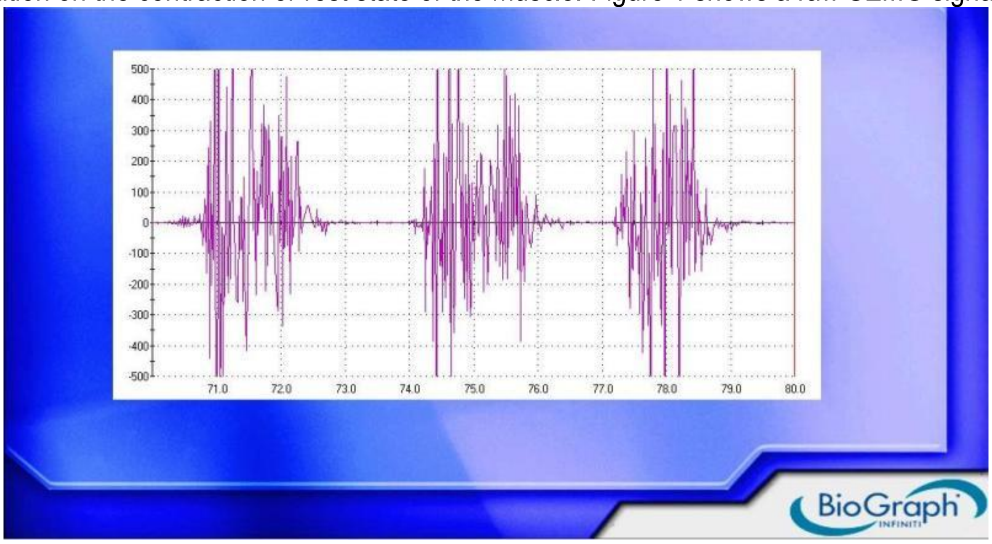


Fig. 1. Raw EMG (three contractions)

In the raw graph the X axis displays time and the Y axis displays amplitude in µV (micro-Volts), both positive and negative, about the axis which centers on zero. As the subject contracts the muscle the number and amplitude of the lines increase; as the muscle relaxes they decrease.

RMS or **R**oot **M**ean **S**quare is a technique for rectifying the raw signal and converting it to an amplitude envelope, to make it easier to view. It represents the mean power of the signal. Figure 2 shows an RMS signal. **Note that MyoTrac3 outputs only RMS, not raw EMG.**

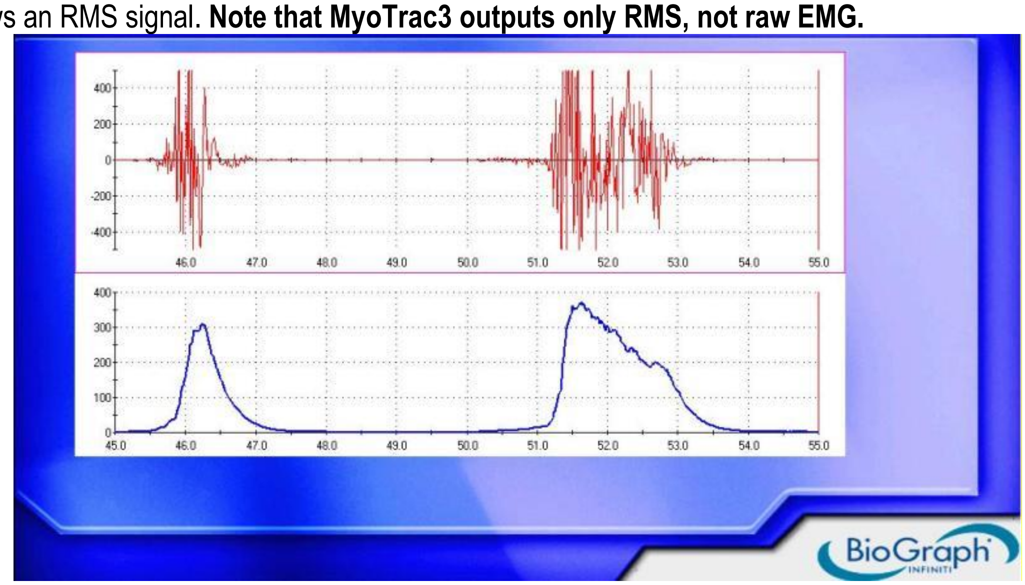


Fig. 2. Raw EMG in red (top) and equivalent RMS EMG in blue (bottom)

SEMG Artifacts

Artifact is unwanted information contained within a signal. An EMG signal is very tiny and sensitive to artifacts. This section presents the different artifacts, how to detect them and how to prevent them.

- Line interference (50/60Hz noise):

This is the most common artifact. It comes from the power line and is transmitted by electrical devices (such as the computer) placed near the EMG data acquisition device (such as MyoTrac3). Figure 3 shows an example of line interference.

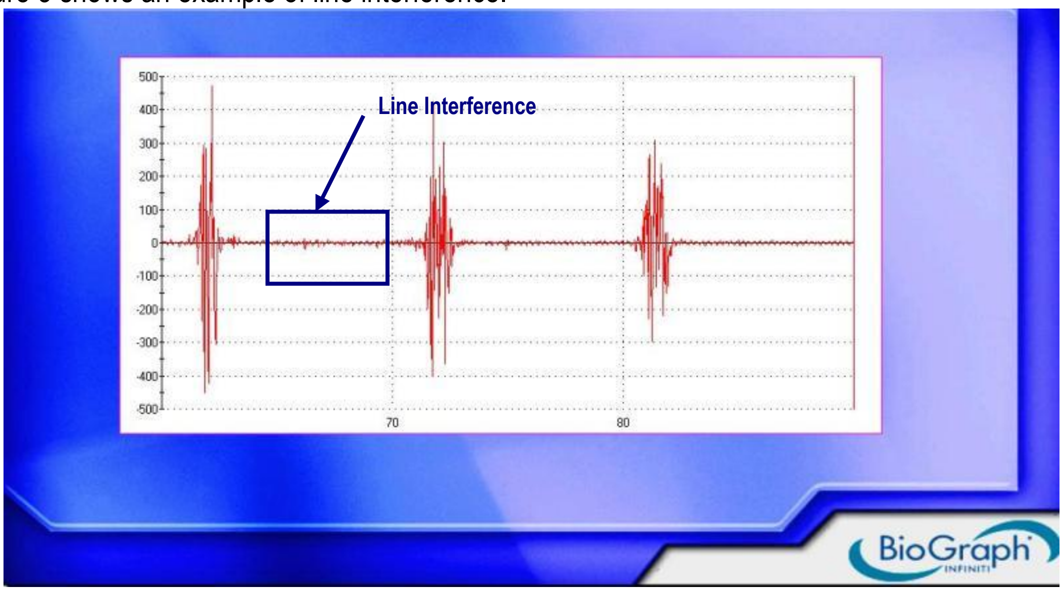


Fig. 3. Raw EMG signal with line interference

This problem can be fixed by applying a Notch filter to the signal, which will remove the 60/50Hz component of the signal. (The choice of 50 or 60Hz depends on the power transmission frequencies used in your region; you must configure your MyoTrac3 accordingly.)

Electronic devices also generate their own frequencies that will not be removed by the Notch filter. Additional precautions must be taken, such as keeping the device 3 feet (1 meter) away from any electronic equipment and 10 feet (3 meters) away from any radio transmitting devices.

- EKG (ECG) artifacts:

EKG signal is generated by the heart. It can be picked up with the EMG signal. Figure 4 shows an example.

EKG artifacts are very difficult to remove from the EMG signal. But they can be avoided by placing the electrodes so that they are not aligned with the axis of the heart activity (avoid transthoracic placement, for instance). Placing the electrodes on the same side of the body usually reduces or removes these artifacts.
If these precautions are not enough, a high-pass filter at 100Hz can be applied to the signal. However, this filters extremely low frequencies from the EMG signal and may remove important information.

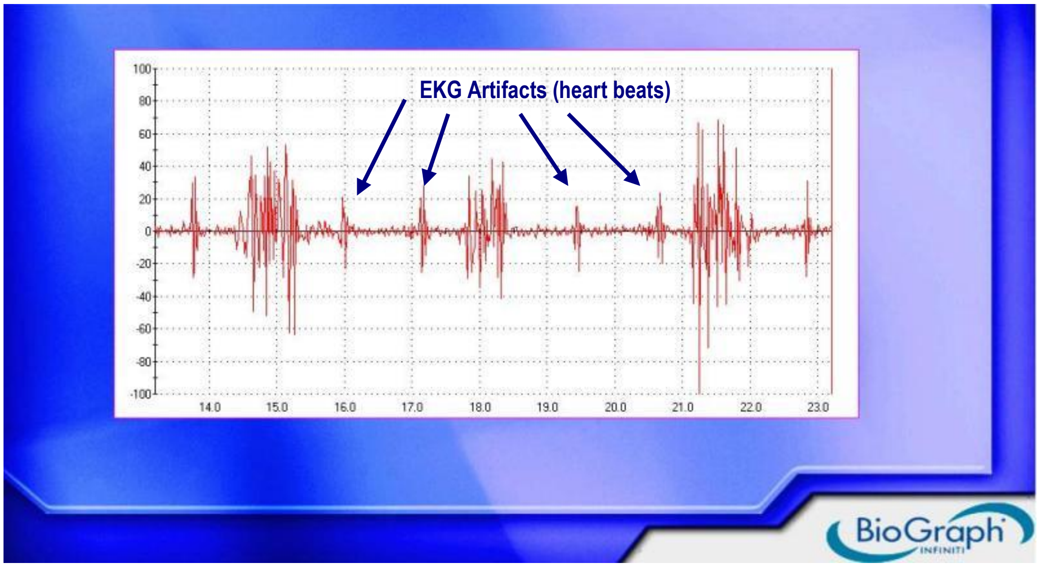


Fig. 4. Raw EMG signal with EKG artifact

- Movement artifacts:

During patient movements, the electrodes can move or the cables be pulled, which may create artifacts in the EMG signal. An example can be seen in Figure 5.

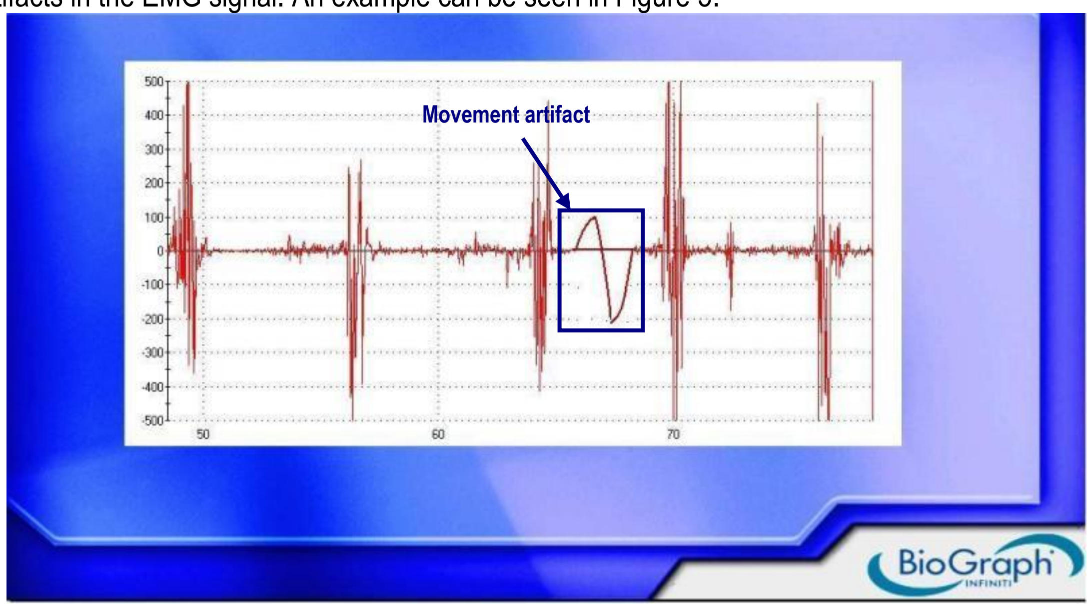


Fig. 5. Raw EMG signal with movement artifact

An artifact caused by pulling can be avoided by using tape or an elastic band to fasten the cables. Electrode movement can be avoided by placing electrodes firmly on the skin to avoid them peeling off. Inter-electrode distance must also be chosen so that electrodes do not push against each other during movement.

A high filter at 20Hz can be applied to the signal (hardware or software) to remove the residual artifact.

These artifacts can also be manually removed from the statistics calculation during the review of the session.

- DC offset artifacts:
This is caused by the difference in the impedance between the skin and the electrodes. It adds an offset to the raw signal (which is normally centered on 0). Proper skin preparation and firm placement of electrodes on the skin generally prevent the problem. If necessary, conductive gel can be added.

- Muscle crosstalk:
Muscle crosstalk is caused by EMG signals coming from other muscles than the one being monitored. Crosstalk can be avoided by choosing the appropriate inter-electrode distance (around 2 centimeters) and by placing electrodes at the middle of the muscle belly.

SEMG Signal Analysis

The analysis of the signal can quickly give accurate, reliable, measurable and objective data to augment and support the subjective reporting of the patient and observations of the therapist. There are two types of analyses: amplitude analysis and temporal analysis.

Amplitude analysis:

- Baseline or resting level: the level of SEMG when the muscle is totally relaxed. It is generally accepted that the SEMG of a muscle at rest should be below 5μV.
- Averaged contraction (mean of SEMG during contraction): this is a good indicator of the level of muscle strength and endurance (while performing an isometric contraction).
- Peak or maximum: this is the maximum SEMG amplitude the muscle can generate.
- Variability: is a good indicator of the neuromuscular stability.

Temporal analysis:

- Onset time or activation time: the time it takes for the muscle to contract.
- Release time or deactivation time: the time it takes for the muscle to go back to rest.

Figure 6 is an illustration of the different measures.

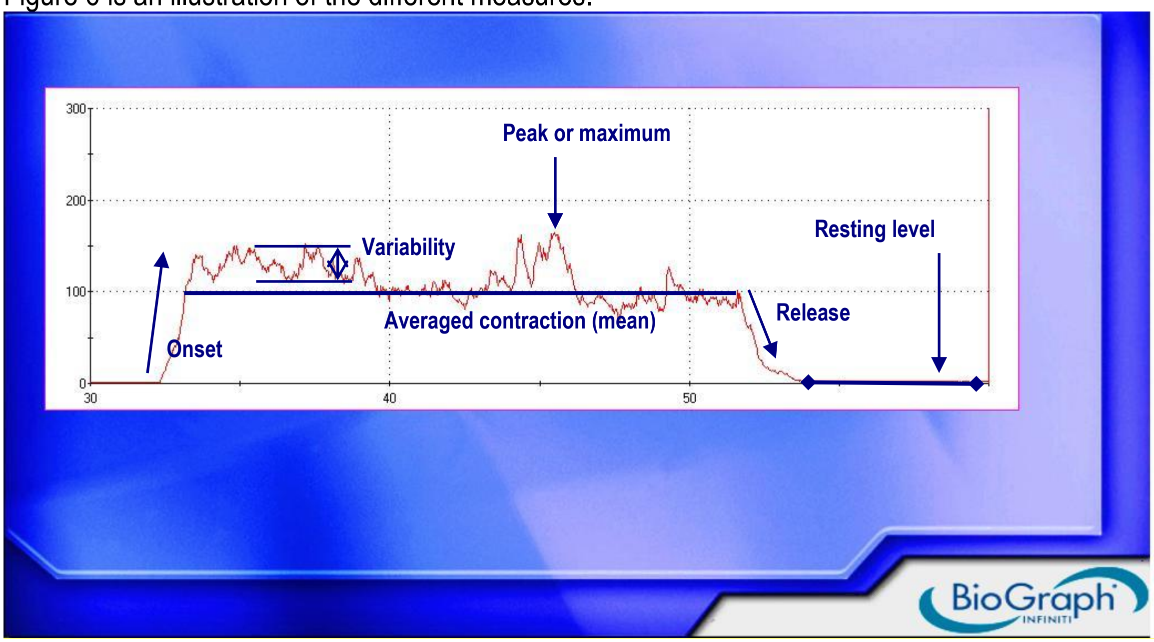


Fig. 6. SEMG measures

Figure 7 shows an SEMG recording of a healthy muscle. Resting level is low, onset and release are quick and the contraction is high.

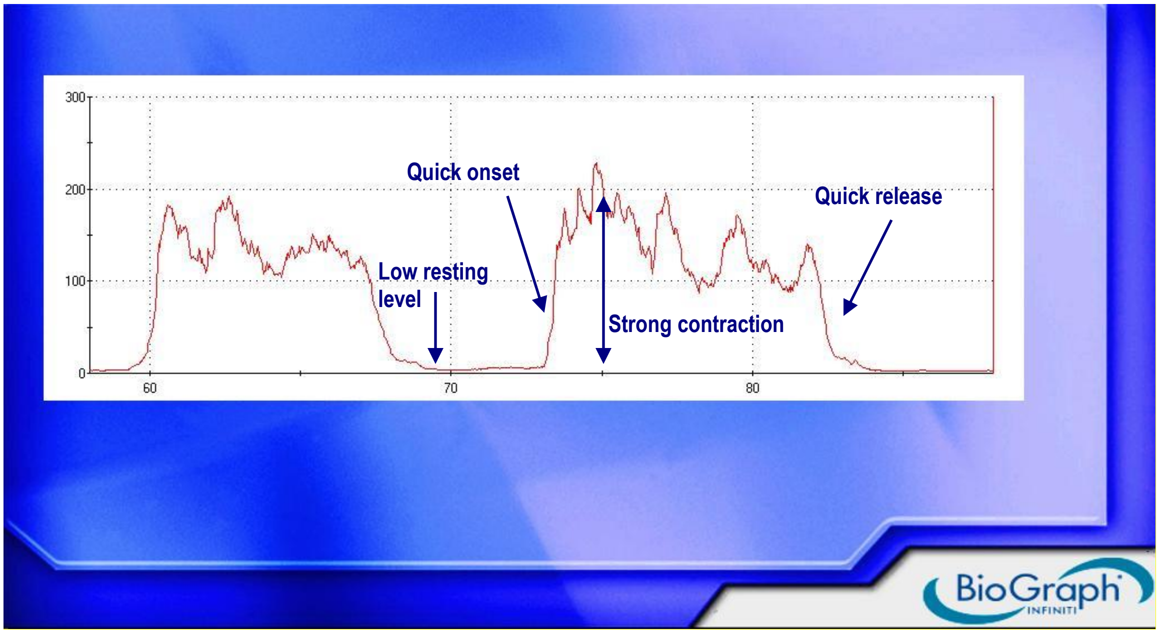


Fig. 7. Healthy Muscle

Figure 8 shows an example of an unhealthy muscle. We can see here that the resting level is too high, the level of contraction is very low and the muscle shows instability.

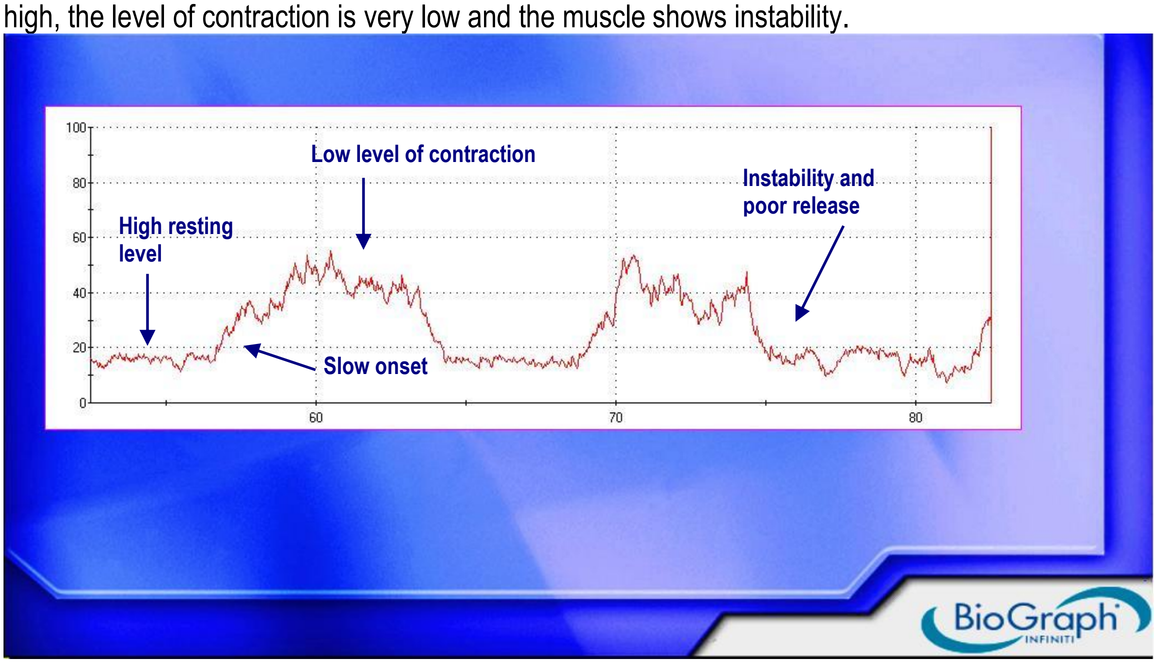


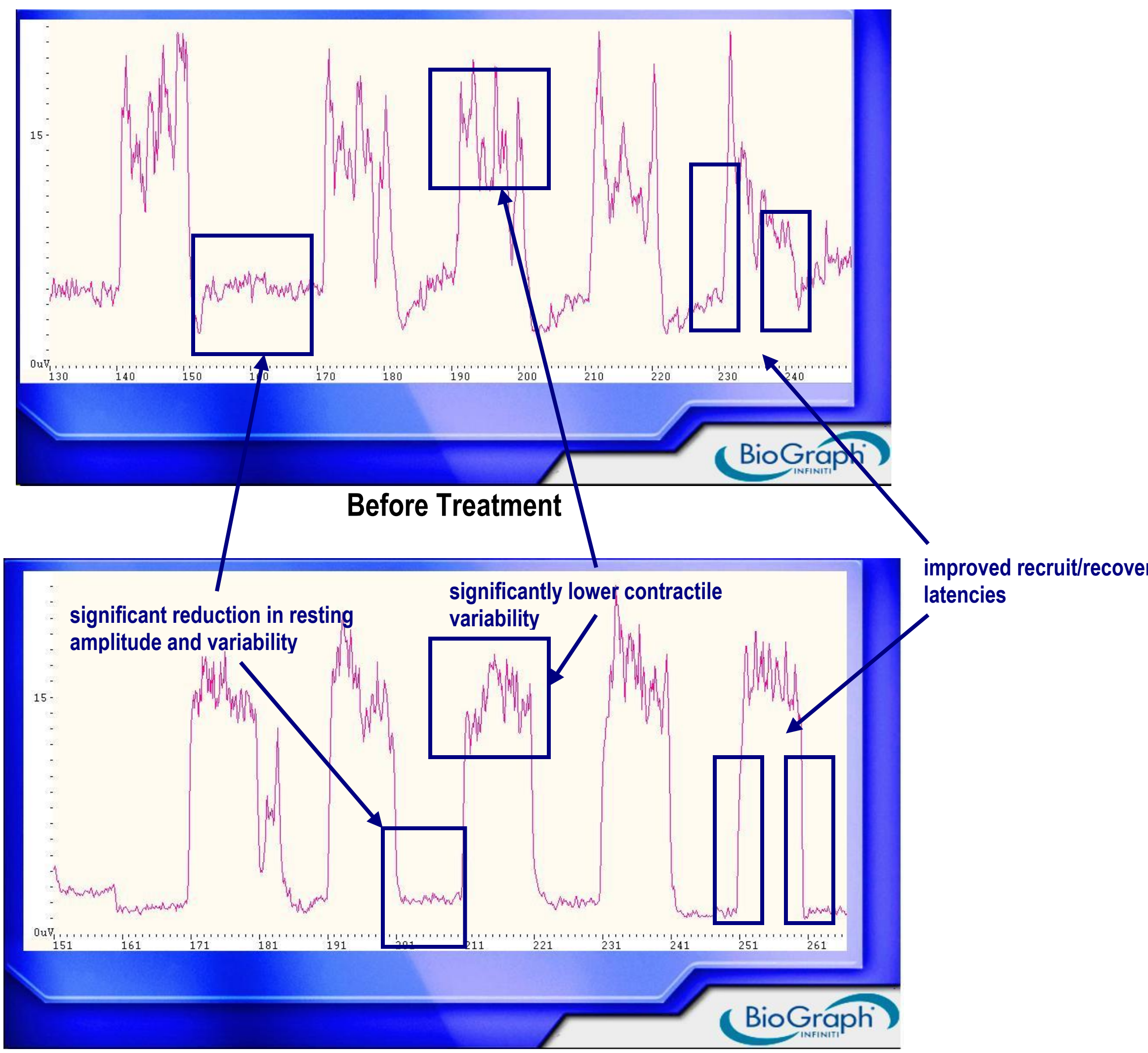
Fig. 8. Unhealthy Muscle

The high resting level indicates a higher muscle tone which, in most cases, will lead to muscle fatigue and/ or muscle pain (the muscle never rests). In this case, the patient should first be trained to relax the muscle. If the patient also presents a poor subjective recognition of tension sensation, biofeedback should be used to improve kinesthetic awareness.

Once the muscle is able to rest, the patient should progressively be trained to increase the level of contraction and the velocity (activation and deactivation time), and finally be trained to gain muscle control (for stability).

Example: application in the treatment of incontinence.
Courtesy of Dr Howard Glazer and the Biofeedback Foundation of Europe (www.bfe.org).

Pre- and Post-biofeedback treatment intra-vaginal SEMG for a 33 year old, one (1) year post partum, multi-parous female, initially reporting multiple daily urine loss on intra abdominal pressure, SUI II, showing complete remission of symptoms after 4 weeks of 2x20min/day biofeedback assisted pelvic floor muscle rehabilitation with the Glazer protocol. Note significant reduction in resting amplitude and variability with improved recruit/recover latencies, significantly lower contractile variability and higher contractile median spectral frequency. Sensory awareness and pelvic muscle control training allows voluntary, rapid onset, sustained closure of the external urethral sphincter, adequate to retain urine during episodes of acute intra abdominal pressure.



After Treatment

Normalization Methods

SEMG measures must be compared to a reference in order to be meaningful. The drawback of SEMG measures is that they can vary significantly between subjects (age and type of skin), muscles, electrode placements (on the same muscle), and from day to day.

Several normalization methods exist; the two most common ones are the following:

- Bilateral comparison: the involved site is compared to the uninvolved site.
- MVC-normalization: MVC is **M**aximum **V**oluntary **C**ontraction. The amplitude is compared to MVC and can be rescaled to % of MVC. MVC is obtained by recording several isometric contractions in the muscle test position (at least three repetitions are required). The maximum values of each repetition are averaged to give the MVC.

Muscle Properties

This section presents very simple concepts that are important to keep in mind when selecting the muscles to measure and when placing the electrodes.

Types of contractions

There are three types of contractions:

- Concentric: the muscle shortens. This happens when the tension is greater than the load.
- Isometric: The muscle stays the same (no movement). The tension is equal to the load.
- Eccentric: The muscle lengthens. The tension is less than the load.

Types of contributions to a movement

Muscles are divided in three groups according to their contribution to a movement:

Agonist muscles: they are the first movers, they initiate the movement; they generate most of the force.
Synergist muscles: they assist the agonist muscles; they generate less force but contribute to the control of the movement.
Antagonist muscles: they act in opposition to the movement; they provide a stabilizing force during the movement.

Examples of agonist/antagonist pairs:

AGONIST	ANTAGONIST
Biceps	Triceps
Deltoids	Latissimus Dorsi
Pectorals	Trapezius/Rhomboids
Abdominals	Erector Spinae
Iliopsoas	Glueteus Maximus
Abductors	Adductors
Quadriceps	Hamstrings
Gastrocnemius/Soleus	Tibialis Anterior

Note that the contribution of a muscle, and consequently its belonging to a group, depend on the movement performed.

Figures 9 and 10 show examples of EMG recordings of agonist, synergist and antagonist muscles.

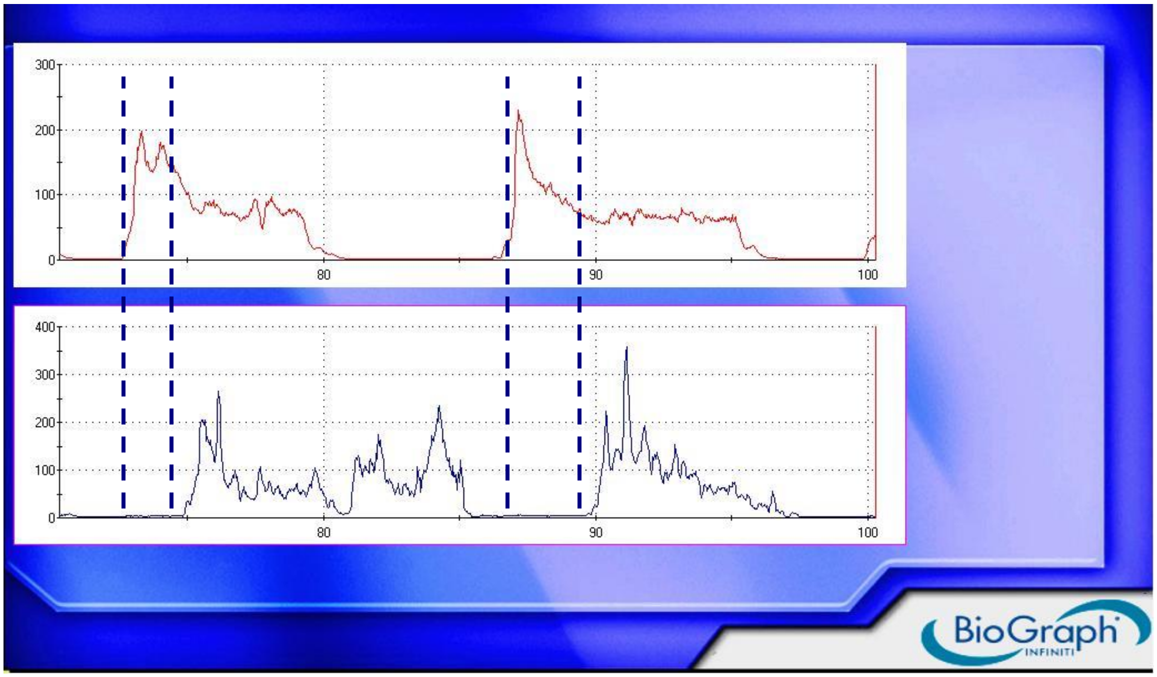


Fig. 9. Agonist Muscle (top) and Synergist Muscle (bottom)

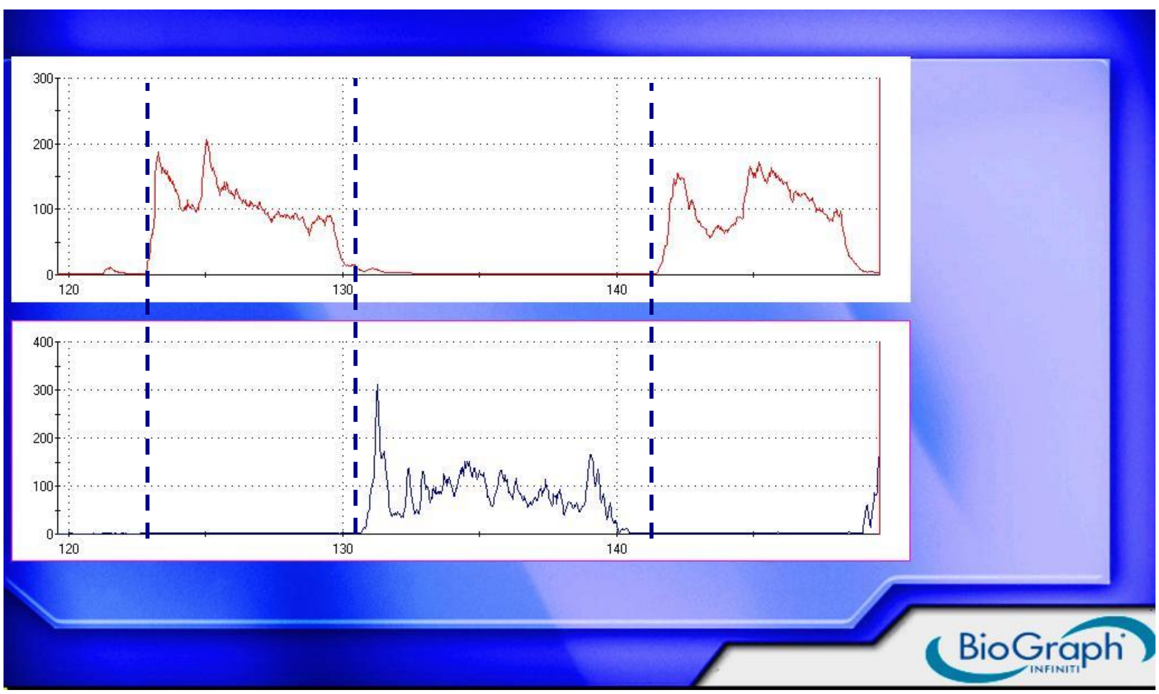


Fig. 10. Agonist Muscle (top) and Antagonist Muscle (bottom)

Three Applications of SEMG

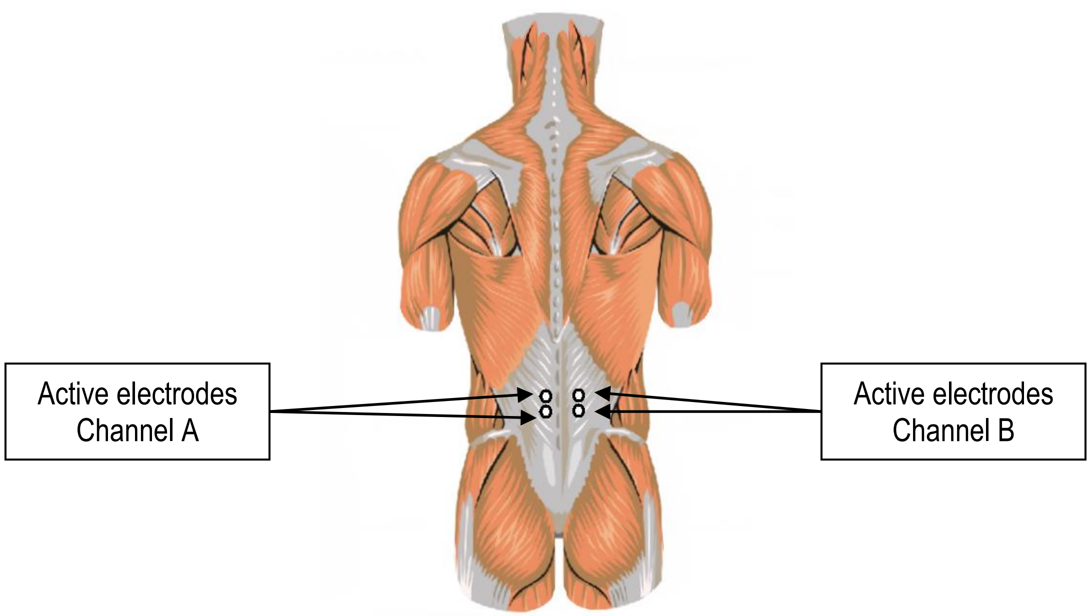
SEMG is widely used in the evaluation of low back pain, patellofemoral pain and unstable shoulder.

Low Back Pain

According to the American Academy of Orthopaedic Surgeons, “four out of five adults will experience significant low back pain sometime during their life”. According to a study from 2006, that included 46,000 people across 16 countries, one in five European adults is suffering from pain and the most common source of pain is back pain (24 %).

Placement of the electrodes:

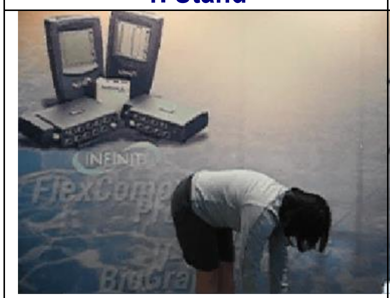
Place the active electrodes in line with the spine, with the patient in a slightly bent position to stretch the skin and aid adhesion. The reference electrodes are placed on the midback (spinous process).



Bending Exercise:
The patient bends and holds at the lowest point for a count of two, then returns to the upright position. This range of motion is repeated three times.

1. Stand

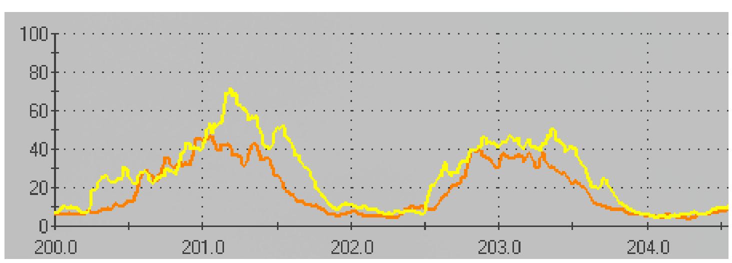
2. Bend



3. At the lowest point, count to 2

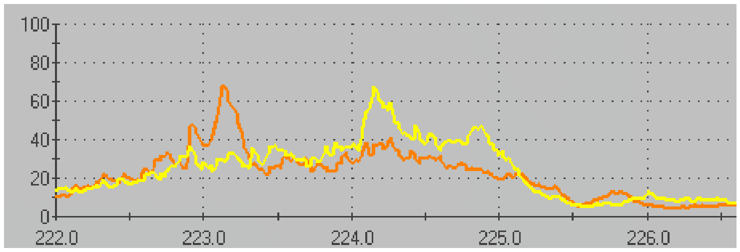
4. Return to the upright position

SEMG shows:
During full flexion, the EMG signal should return to baseline, showing relaxation of muscles. Bi-laterally both signals should be equal in intensity (within 35%) throughout the range of motion.



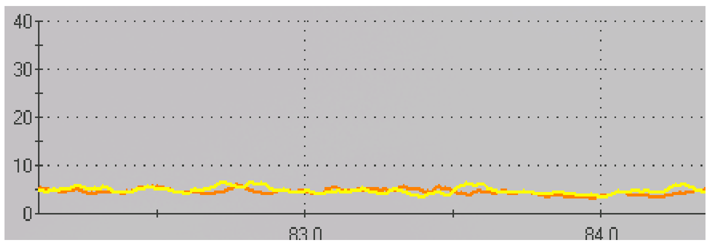
Healthy Muscle (one repetition)

No resting of the muscles during full flexion leads to fatigue of the muscles. If one signal is higher than the other, it also indicates a level of dysfunction.



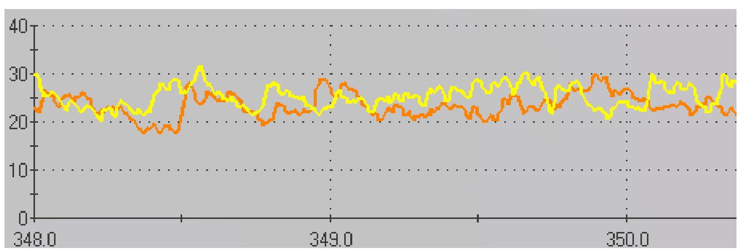
Unhealthy Muscle (one repetition)

Both muscles return to low levels of activation (below 5μV) when at rest position.



Healthy Muscle at rest position

Muscles activated during rest lead to fatigue.



Unhealthy Muscle at rest position

Patellofemoral Pain Evaluation

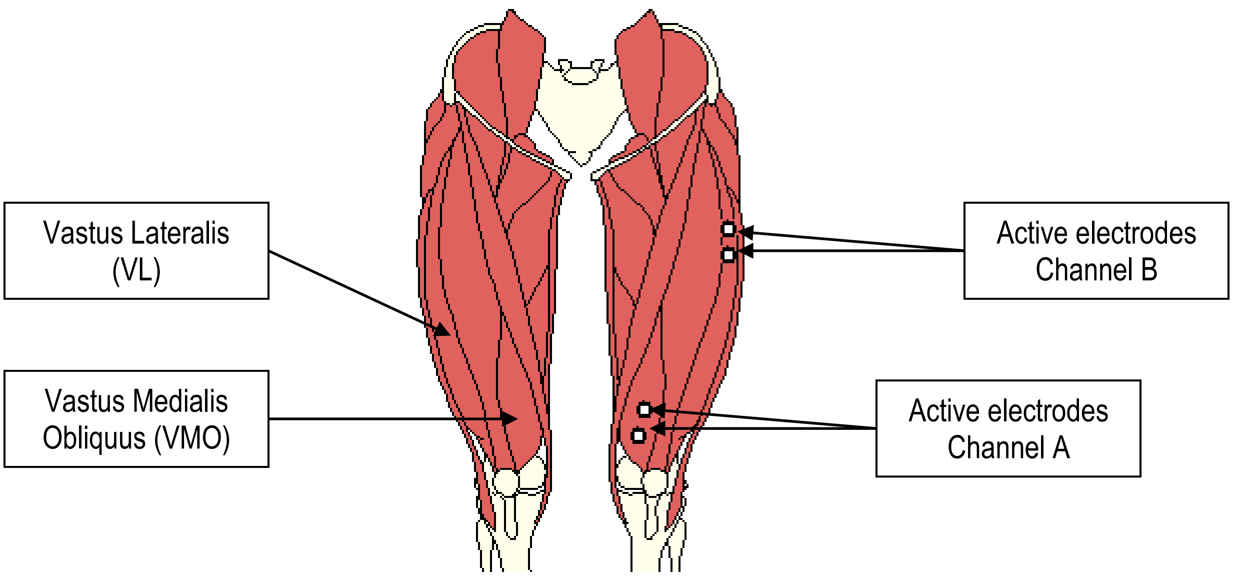
Patellofemoral pain is a common ailment affecting one in four of the general population. It is caused by a variety of factors including abnormal lower limb mechanics, Vastus Medialis Obliquus (VMO) insufficiency, tight lateral structures and tight anterior and posterior muscles.

The condition often develops gradually and is characterized by a diffuse ache of the anterior knee. Note that another common pain is Chondromalacia, which is distinct from Patellofemoral pain. The former is caused by a softened and dissured patellar under-surface as seen during diagnostic imaging or surgery.

The VMO muscle is the only dynamic medial stabilizer of the patella, and is active throughout the full range of the extension of the knee.

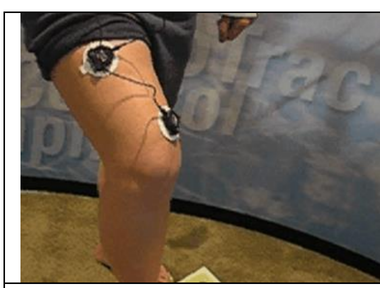
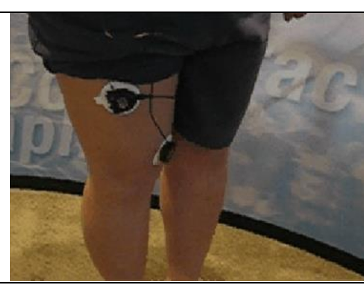
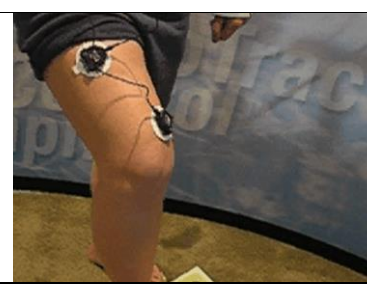
Placement of the electrodes:

Place the active electrodes of channel A on the Vastus Medialis Obliquus (VMO) and the active electrodes of channel B on the Vastus Lateralis (VL), as shown in the picture. The reference electrodes have to be placed proximally (above the active electrodes, closer to the trunk).



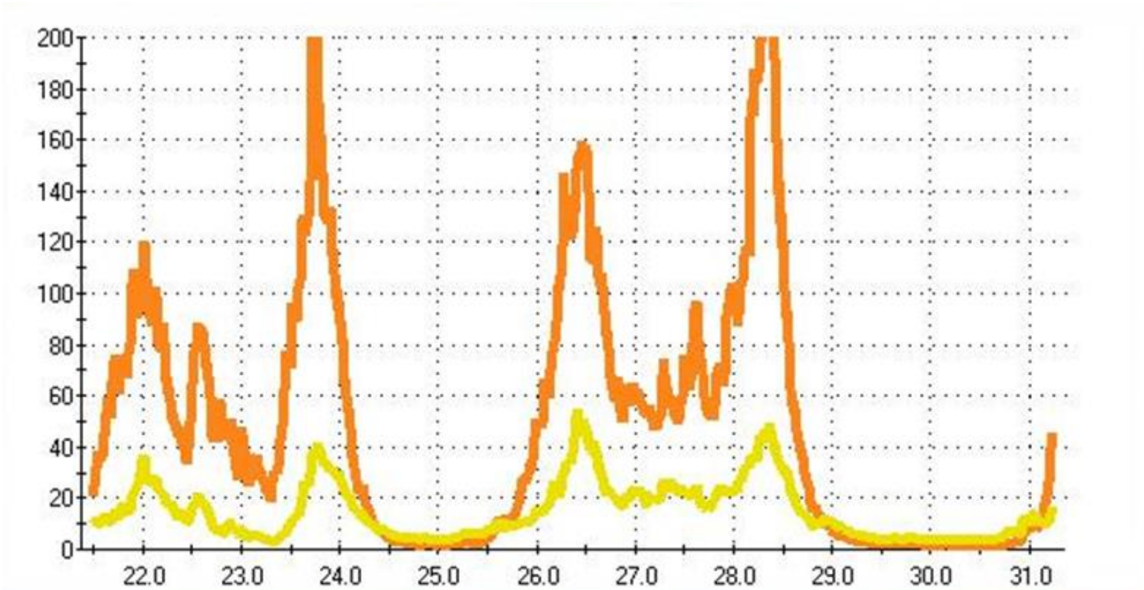
Step-down Exercise:

The involved leg should remain on the step block. The good leg steps up, joining the other leg, then steps down.

		
Start with leg down	**Step up**	**Then step down**

SEMG shows:

EMG studies of non-painful knees show that the ratio of VMO to VL activity is one-to-one and that VMO is tonic in nature. The ideal is two-to-one. In knees with patellofemoral pain the ratio is less than one-to-one.

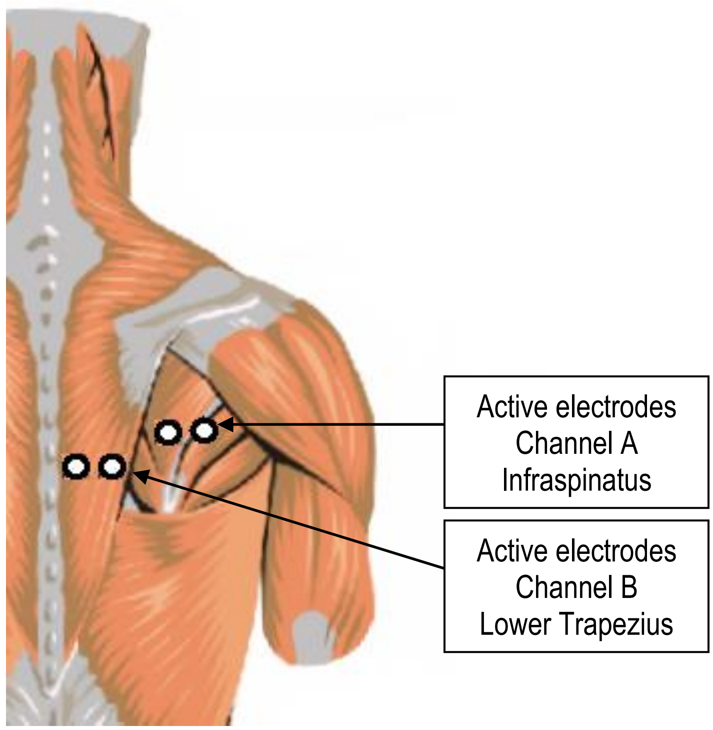


Unstable Shoulder Evaluation

Anterior shoulder instability is a common athletic complaint associated with overuse, joint laxity, post traumatic dislocation and muscle imbalance. This protocol uses targeted muscle feedback of external rotators to perfect motor skills.

Placement of the electrodes:

Place active electrodes horizontally over Infraspinatus (channel A) and the lower trapezius (channel B), as shown in the picture. Do not place them over the posterior deltoid. Place the reference electrodes below the active ones, as far as you can.



Exercises:

The following exercises guide you through the range of motions that the patient will work through over time, as they develop the control to maintain the correct position with the aid of EMG feedback. The key aim is to ensure that the patient can maintain control within the limits that they have set during the range of motion. If they can, they should move on to increasingly complex movements.

Range of Motion 1: Tightening of Rotator Cuff

Guide the patient to pinch their shoulder blades together to the neutral position, in order to glide and hold the humeral head back. When held in this position, note the EMG level. This must be successfully performed 100 times in sets of 10 prior to progressing to the active movements (next exercises). This may take several sessions.

Range of Motion 2: Forward Flex, Flexed Elbow

Instruct the patient to forward flex the adducted and neutral rotated shoulder to 90 – 100 degrees, with the elbow in flexion.

As the shoulder is flexed, ensure the patient is still pinching the shoulder blades to achieve the threshold setting noted in Range of Motion 1.

When the patient can perform 100 repetitions, move on to the next exercise.

Range of Motion 3: Forward Flex, Straight Elbow

Instruct the patient to forward flex the adducted and neutral rotated shoulder to 90 – 100 degrees, with the elbow held straight.

As the shoulder is flexed, ensure the patient is still pinching the shoulder blades to achieve the threshold setting noted in Range of Motion 1.

When the patient can perform 100 repetitions, move on to the next exercise.

Range of Motion 4: Abduction with Flexion

Instruct the patient to abduct their arms with the arm bent from their slides, while maintaining the shoulder blade pinched.

When the patient can perform 100 repetitions, move on to the next exercise.

Range of Motion 5: Abduction, Straight Elbow

Instruct the patient to abduct their arms from their slides with the arm straight, while maintaining the shoulder blade pinched.

When the patient can perform 100 repetitions, move on to the next exercise.

Range of Motion 6: Abduction from Flexion

Instruct the patient to abduct their arms from flexion with the arm bent, while maintaining the shoulder blade pinched.

When the patient can perform 100 repetitions, move on to the next exercise.

Range of Motion 7: Abduction from Flexion with Reach-Back

Instruct the patient to abduct their arms from flexion with the arm bent and continue the motion by reaching their hand behind their head, while maintaining the shoulder blade pinched.

When the patient can perform 100 repetitions, move on to the next exercise.

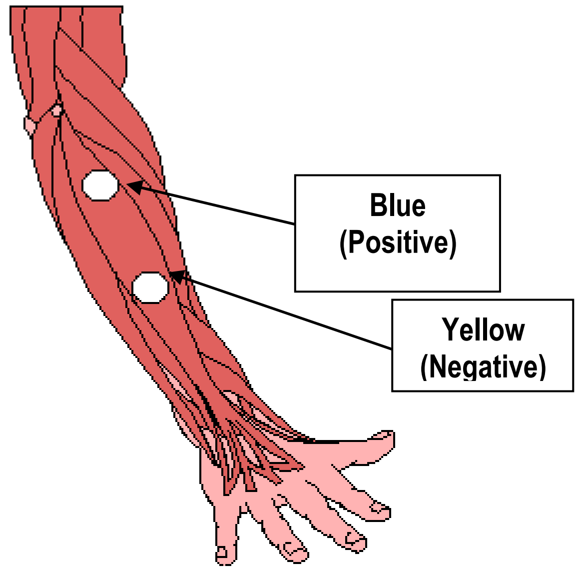
Electrodes - General Instructions

Before applying electrodes, be sure the skin surface is cleaned and dried. If necessary, shave excess body hair. Make sure the electrodes are placed firmly on the skin and that there is good contact between the skin and electrodes.

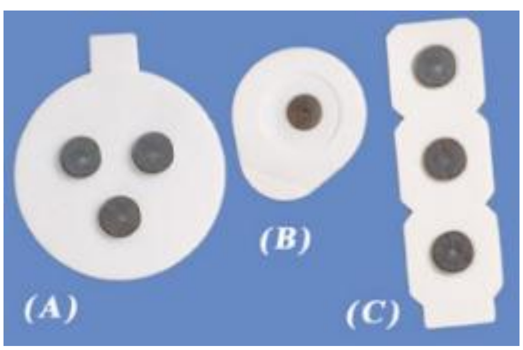
It is recommended to put conductive electrode paste or cream on the EMG electrodes (grey area only) before applying them to the skin.

Place the active electrodes (positive and negative) along the muscle fibers as illustrated.

Then place the reference electrode (black connector) anywhere on the body.



Example of placement
(Wrist and Finger Extension)

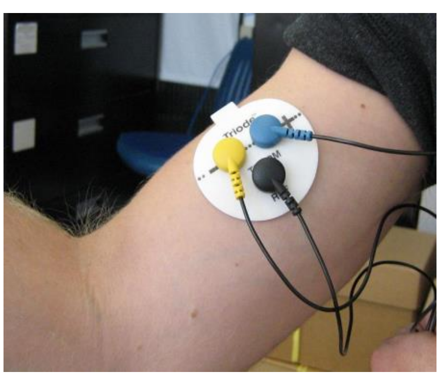


For SEMG, the following electrodes must be used:

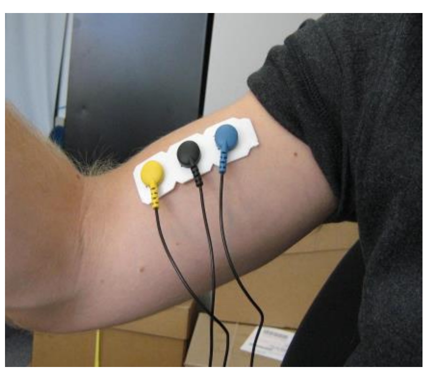
(A) T3402M – Triode electrode with standard 2cm spacing of silver silver-chloride electrodes.

(B) T3425 - UniGel electrodes (pre-gelled single electrodes, for sensitive placements on dry skin).

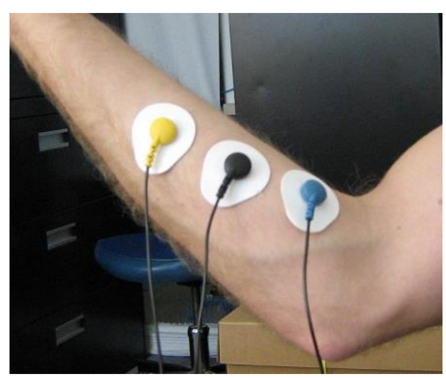
(C) T3404 - Single strip electrodes.



T3402M – Triode electrode



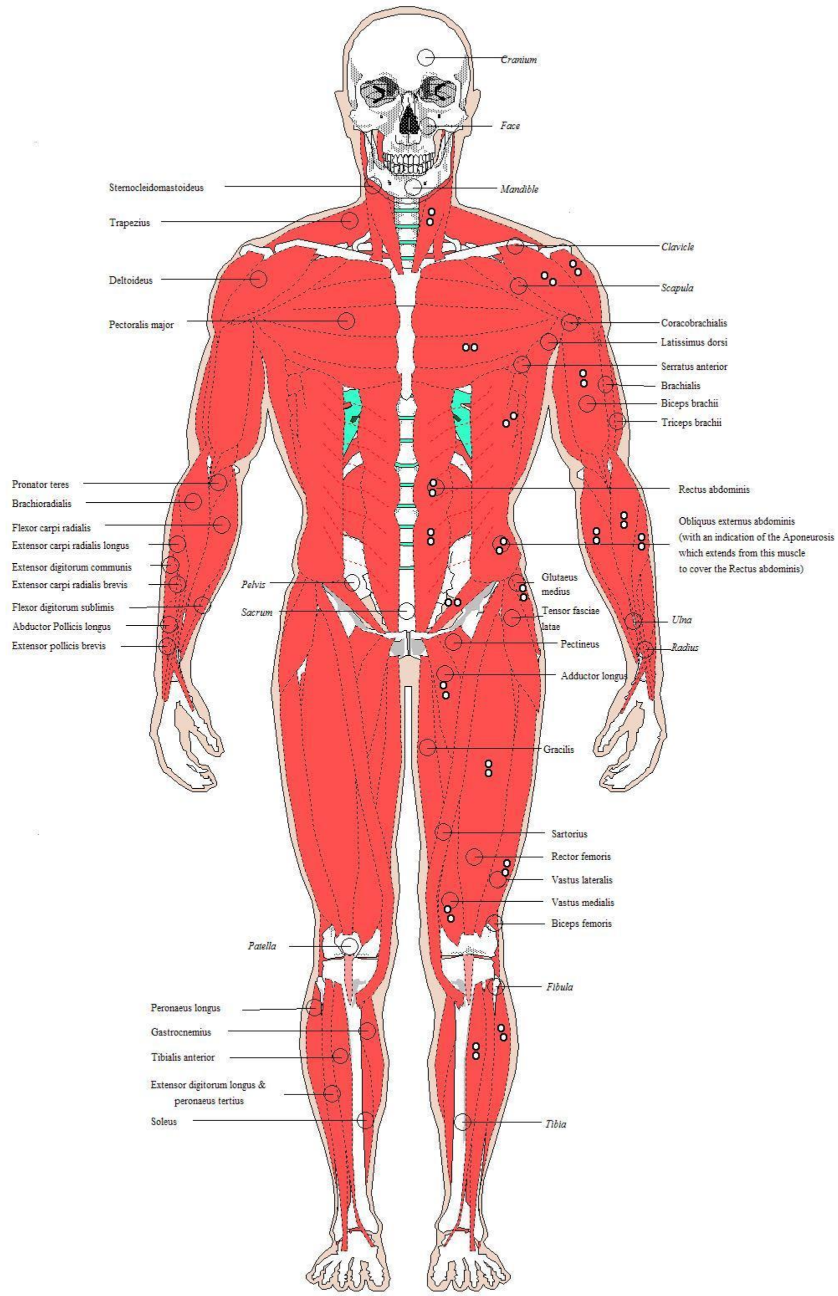
T3404 - Single strip electrodes



T3425 - UniGel electrodes

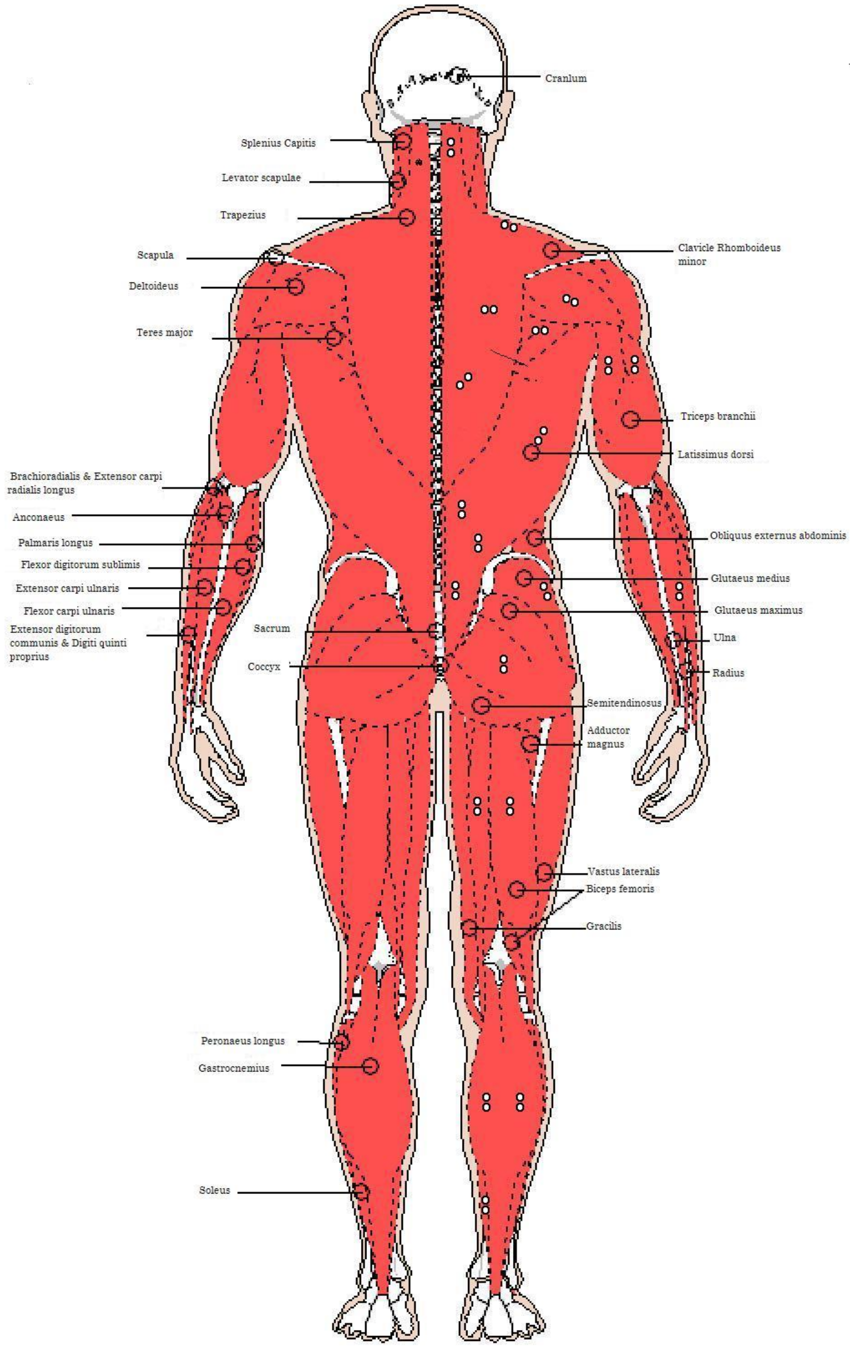
The following two pages show electrode placement on the different body areas.

SEMG – Front View



MUSCLES, SUPERFICIAL LAYER, ANTERIOR VIEW

SEMG – Back View



MUSCLES, SUPERFICIAL LAYER, POSTERIOR VIEW

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