



# Medical Physics II

2<sup>nd</sup> semester

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# Lectures 2

## Electromyography

# What is EMG

Muscle contraction is due to a change in the relative sliding of thread-like molecules or filaments.

## Actin and Myosin

Filament sliding is produced by an electrical phenomenon (ACTION POTENTIAL, **AP**).

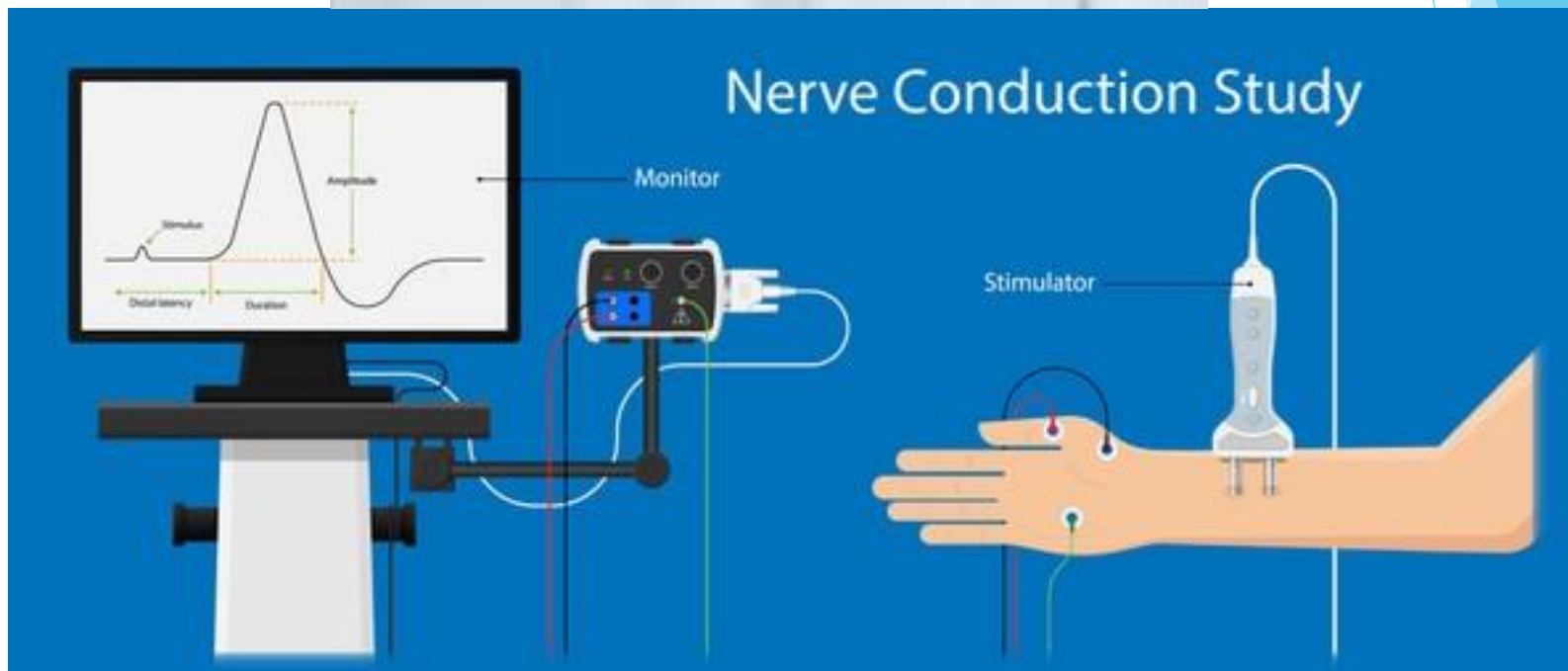
The recording of muscle APs is called **electromyography** (EMG).

The record is known as an **electromyogram**.

# Electromyogram (EMG)

- ▶ **Electromyography (EMG) measures muscle response or electrical activity in response to a nerve's muscle stimulation.**
- ▶ The test is used to help **detect neuromuscular abnormalities.**
- ▶ An **audio amplifier** is used so the **activity can be heard.**
- ▶ **EMG measures** the **electrical activity** of muscles **during rest, slight contraction, and forceful contraction.**
- ▶ **Muscle tissue does not normally produce electrical signals during rest.**
- ▶ When an **electrode is inserted**, a **brief period of activity** can be **seen on the oscilloscope**, **but** after that, **no signal should be present.**

# Electromyogram (EMG)

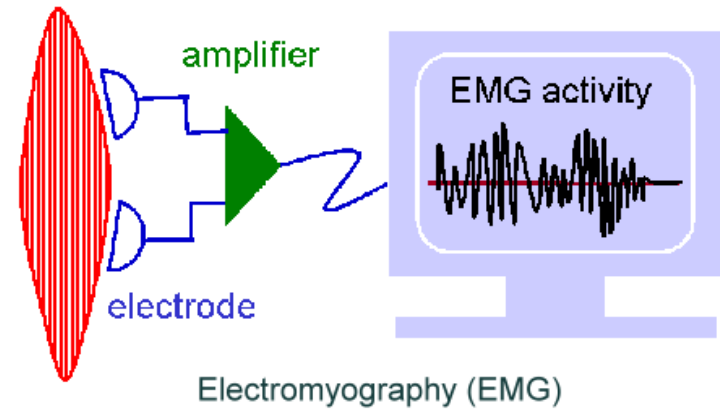
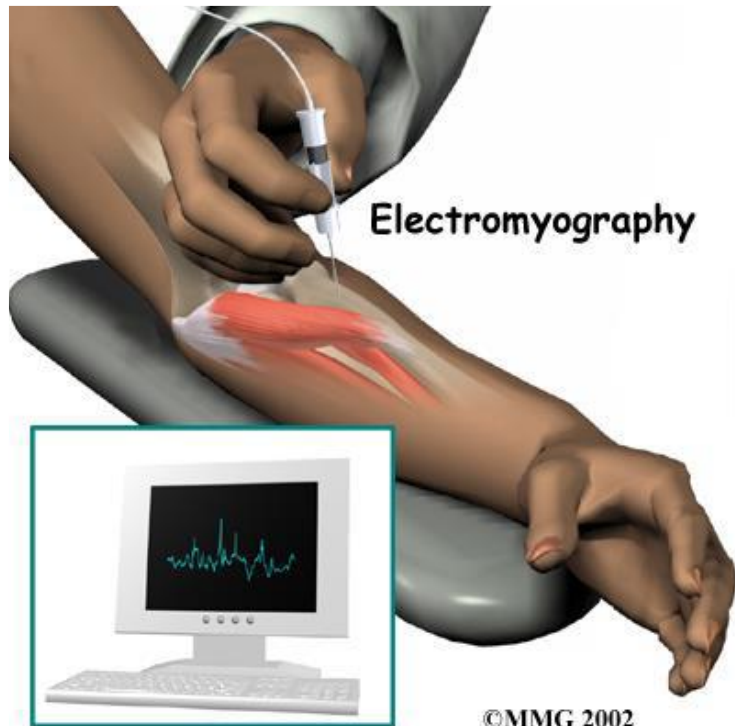


# The Requirements of EMG Test:

- 1- Generally, **fasting** is **not** required before the test.
- 2- In some cases, **cigarettes and caffeinated beverages**, such as **coffee, tea, and cola**, may be **restricted two to three hours before** testing.
- 2- **Notify** a **doctor** of **all medications** (prescribed and over-the-counter) and herbal supplements you are taking.
- 3- **Notify** **A doctor** if you have a **pacemaker**.

# Mechanism of EMG

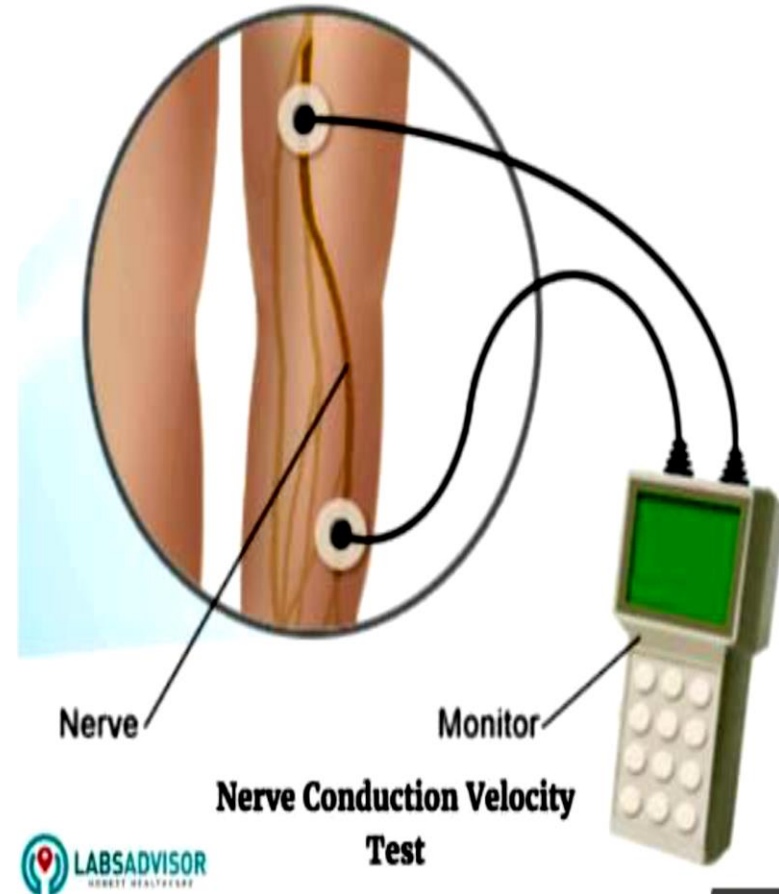
- 1- **You will be asked** to **remove** any jewelry, hairpins, eyeglasses, hearing Aids or other metal objects that **may interfere with the procedure**.
- 2- The **skin** will be **cleansed** with an antiseptic solution. Next, a **fine, sterile needle** will be **inserted into the muscle**. A **ground electrode** will be **positioned under the arm or leg**.
- 3- **Five or more needle insertions** may be necessary for the test. May experience **slight pain** with the **insertion of the electrode**.
- 4- **If** the test is **painful**, **must** tell the examiner because this can **interfere with the results**.
- 5- The **electrical activity from your working muscle** will be **measured** and **displayed** on the **oscilloscope**.
- 6- An **audio amplifier** may also be **used** so that both **the appearance and sound of the electrical potentials** can be **evaluated**.





## Nerve Conduction Study (NCS):

- **NCS** measures the **amount and speed** of conduction of an electrical impulse through a nerve.
- **NCS** can **determine nerve damage and destruction** and is often performed **simultaneously** with EMG.
- **Both procedures** help to **detect the presence, location, and extent of diseases** that damage the nerves and muscles.
- **Sometimes** referred to as **nerve conduction velocity (NCV)**.



- ▶ **An EMG test:** Looks at the electrical signals your muscles make when they are at rest and being used.
- ▶ **A nerve conduction study:** Measures how fast and how well the body's electrical signals travel down nerves.
- ▶ **Risks:** During a nerve conduction study, you may feel a little pain or cramping during an EMG test and may have a tingly feeling, like a mild electric shock.

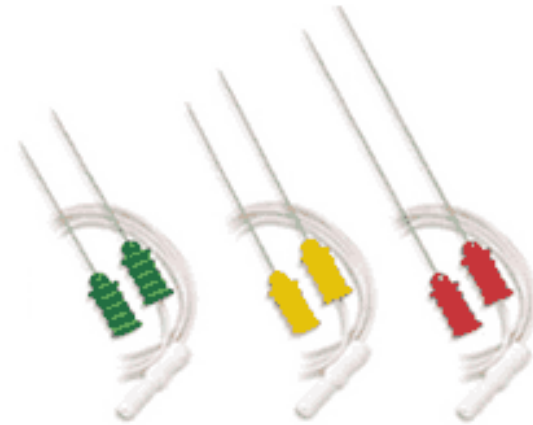
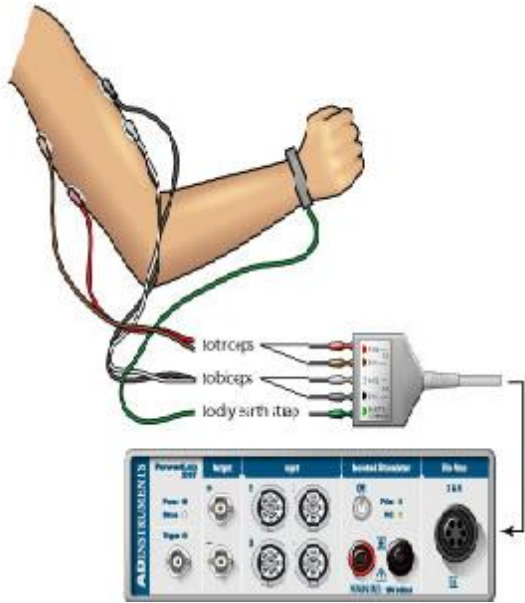
# When is the EMG test done:

- 1- Muscle weakness.
- 2- Tingling or numbness in arms, legs, hands, feet, and face.
- 3- Muscle cramps, spasms, and twitching.
- 4- Paralysis of any muscles.

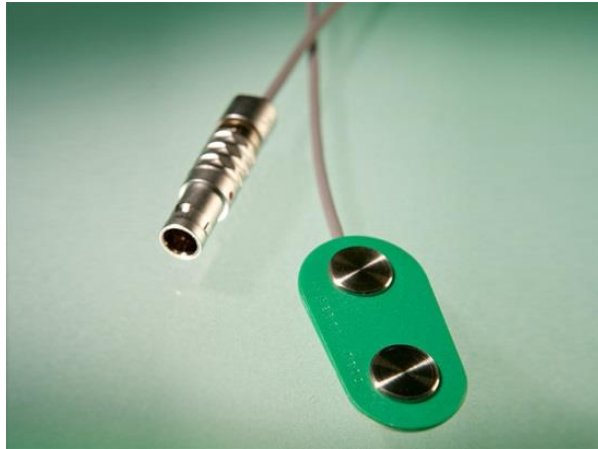
# Recording Methodology

- ▶ Electrical potential difference measured between two points  
→ bipolar electrode configuration used
- ▶ **Bipolar Electrode Types**
  - ▶ Fine Wire
  - ▶ Needle
  - ▶ Surface
    - ▶ Most common, less invasive
    - ▶ Silver-silver chloride electrodes
- ▶ **Electrode Placement**
  - ▶ Overlying the muscle of interest in the direction of the predominant fiber direction
  - ▶ Subject is **GROUNDED** by placing an electrode in an inactive region of body

# EMG Electrodes



Fine wire



Surface  
Electrodes

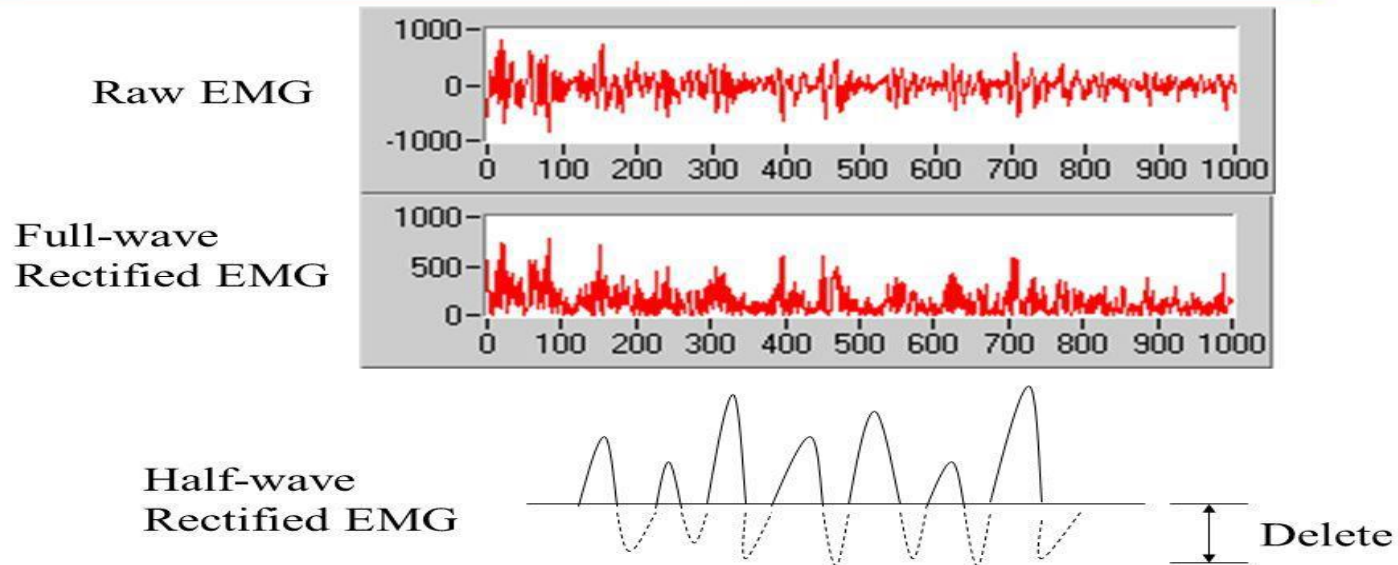


Needle<sup>13</sup>  
electrode

# EMG Signal Processing :

- ▶ The purpose of rectifying the signal is to ensure the signal does not average to zero, because the raw EMG signal has positive and negative components, two types of rectification are used:
- ▶ **Full-wave rectification:** adds the EMG signal below the baseline to be with the signal above the baseline to make a conditioned signal that is all positive.
- ▶ **Half-wave rectification:** discards the portion of the EMG signal that is below the baseline. In doing so, the average of the data is no longer zero therefore, it can be used in statistical analyses.

## Rectification - Types

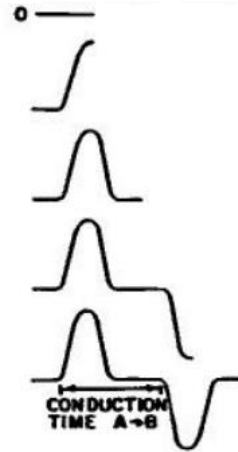




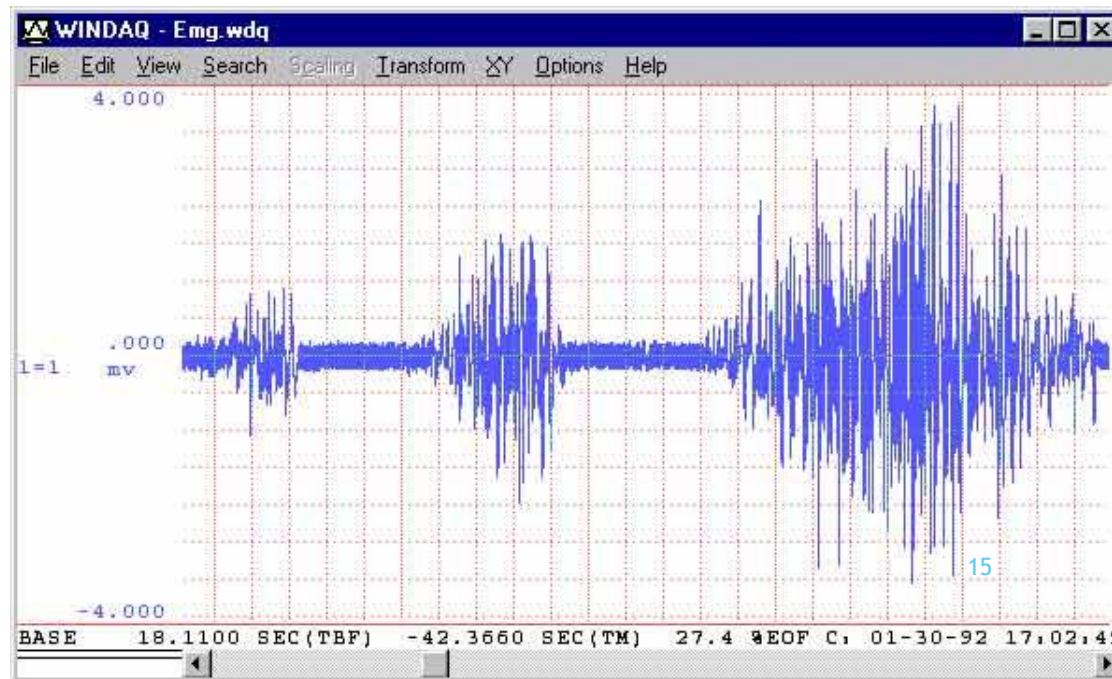
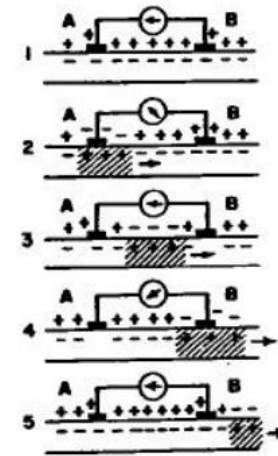
# Physiological Basis

► Hypothetical EMG from a single Muscle cell

Potential difference between electrodes  
Polarity A- B+ up, A+ B- down



Time instances 1 to 5



# Results Test of EMG :

**If results are not normal**, it can indicate various conditions. Depending on which muscles or nerves are affected, it may mean one of the following:

1- **Carpal tunnel syndrome**, a condition that affects nerves in the hand and arm. It's usually not serious, but it can be painful.

2- **Herniated disc**, a condition that happens when a part of your spine, called a disc, is damaged. This puts pressure on the spine, causing pain and numbness.

3- **Guillain-Barré syndrome**, an autoimmune disorder that affects the nerves. It can lead to numbness, tingling, and paralysis. Most people recover from the disorder after treatment.

4- **Myasthenia gravis**, a rare disorder that causes muscle fatigue and weakness.

5- **Muscular dystrophy**, an inherited disease that seriously affects muscle structure and function.

6- **Charcot-Marie-Tooth disease** is an inherited disorder that causes nerve damage, mostly in the arms and legs.

7- **Amyotrophic lateral sclerosis (ALS)**, also known as **Lou Gehrig's disease**. This progressive, ultimately fatal, disorder attacks brain and spinal cord nerve cells. It affects all the muscles that move, speak, eat, and breathe.



# Analyzing the EMG Signal

## Amplitude & Frequency

- ▶ More MU → more amplitude, more spikes, and more turns in the signal.
- ▶ Change in firing rate → change in the frequency content of EMG.
- ▶ Change in muscle fiber type → change in AP velocity, change in EMG frequency.
- ▶ EMG is the spatial and temporal summation of APs

# Factors Influencing Signal Measured

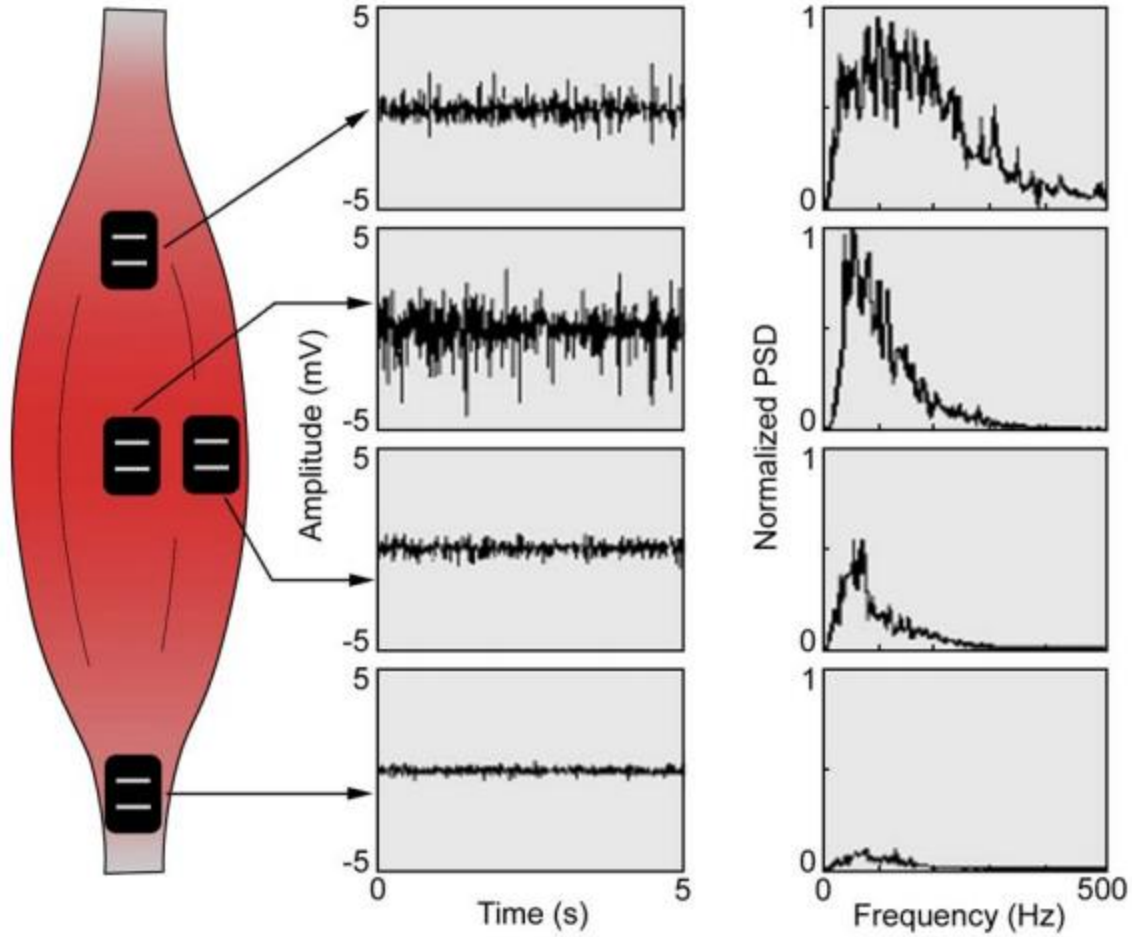
## ▶ Geometrical & Anatomical Factors

- ▶ Electrode size
- ▶ Electrode shape
- ▶ Electrode separation distance with respect to muscle-tendon junctions
- ▶ Thickness of skin and subcutaneous fat
- ▶ Misalignment between electrodes and fiber alignment

## ▶ Physiological Factors

- ▶ Blood flow and temperature
- ▶ Type and level of contraction
- ▶ Muscle fiber conduction velocity
- ▶ Number of motor units (MU)
- ▶ Degree of MU synchronization

# Effect of electrode position on EMG



# What can be learned from an EMG?

- ▶ Time course of muscle contraction
- ▶ Contraction force
- ▶ Coordination of several muscles in a movement sequence
  - ▶ These parameters are DERIVED from the amplitude, frequency, and change of these over time of the EMG signal
- ▶ Field of Ergonomics: from the EMG, conclusions about muscle strain and the occurrence of muscular fatigue can be derived as well