

Electromyography

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"Electromyography is a seductive muse" (Carlo DeLuca)

1 EMG

- Measurement of electrical signals produced by muscle (few microvolts)
- Clinical and research setting
- Old school EMG: lie detector equipment
- Amplification: differential amplifier
 - Don't want external noise
 - Need isolation from power supply b/c human subjects
 - Surface or invasive electrodes
 - Surface: non-invasive, simple to use, doesn't require certification/special training, samples entire muscle, relatively reproducible; requires good skin prep
 - * Use a regular metal snap to connect to others
 - * Need good skin prep because everything in the way increases impedance
 - * Shave if necessary, abrade skin, alcohol pad, apply electrodes
 - * Single, bar, array electrodes
 - * Some may be reusable, have to be sterilized, electrolyte gel; vs. disposable
 - * Can have active pickups, amplify on the spot

- * Pair of electrodes must be placed in direction of muscle fibers
 - * Don't want to be in the innervation zone of muscle, gets high-frequency action potential of nerves
- Invasive: not distorted by skin, fat, hair, sweat; can pick up signals from deep muscles; samples small number of motor units; requires certification
 - * Confirm right placement by stimulating electrode
 - * Needle or fine wire; slides in and out very easily; used for small contractions
- EMG interference pattern
 - Result of many action potentials, different amplitudes and phase
- Motor unit recruitment firing pattern:
 - Small amplitudes at first, lower frequencies at first
- Need to standardize electrodes and how far apart they are
 - Difficult to get exactly reproducible results
 - EMG normalization: maximal voluntary isometric contraction (MVC): simply do maximum effort; activity should isolate muscle as much as possible, and to actually get the maximum effort
 - * May try to normalize to some other standard activity; e.g., walking or lift a standard weight
 - Problem: crosstalk from nearby muscles
 - * Minimize with proper electrode spacing and good skin prep
 - * Can also use double-differential method
- Clinical EMG used for evaluating nerve health, etc.
 - Nerve conduction study: stimulate nerve, see if muscle reacts
- Measure how long it takes for muscle stimulus to travel down arm
- M-wave: normal muscle response
- F-wave: when stimulating in the middle of an axon causes the signal to bounce back small; not commonly used
- H-reflex: measure of motor neuron, spinal cord excitability:

- Excitability: a lowered threshold for activity; when you start doing something your muscles continue to do it
- Research applications: measure activity of muscles during various activities
 - Larger EMG amplitude qualitatively related to force generation, but only very loosely
- Pennation angle: angle of muscle fibers;
 - Force generating capacity is directly related to cross-sectional area
 - Bi-pennate muscles are weird
- Average amplitude of EMG is zero; need to rectify and smooth (RMS) and then normalized
 - Want end result that qualitatively describes the force generation pattern
 - Need to determine when the muscle is considered "on" – somewhat arbitrary
- Beware of 60Hz frequency
- EMG filters:
 - HPF at 10-20Hz: low frequencies usually are due to "motion artifact"
 - LPF at less than half sampling frequency
- Calculate mean and median frequency
- Factors affecting EMG frequency content:
 - Conduction velocity
 - Muscle diameter (affects the shape of action potentials)
 - Slight effect of firing rate
- Signal is not stationary, so cannot perform FT
- Moving screws everything up: changes shape and changes moment arms
- Fatigue is inability to maintain the required force:

- Peripheral causes: metabolic processes, issues in muscle, neuromuscular junction
 - Central causes: failure of central nervous system to drive muscle, not a motivational thing (can think of it as an optimization scheme)
 - In sub-maximal isometric contractions, EMG amplitude goes up with fatigue (as more motor units are recruited)
 - Women more fatigue-resistant than men
 - Elderly are more fatigue-resistant than young (due to how fatigue research is done)
 - Central activation ratio (CAR): ratio of voluntary to full stimulated force
- Newer EMG method: magnetic stimulation
 - Transcranial magnetic stimulation: voodoo stuff