Electrical Stimulation for Motor Responses

...from twitch to tetany...

"The stimulation seemed so scary when you suggested it but I can see the muscle working!"

Potential Goals:

- Electrical Stimulation is often described in terms of the goals it is being used to accomplish.
  - Edema reduction
  - Pain reduction
  - Muscle strengthening
  - Muscle re-education
  - Reduction in muscle guarding
Potential Goals that require a motor response:

- Edema reduction
- Pain reduction
- Muscle strengthening
- Muscle re-education
- Reduction in muscle guarding

What's in a name?

- Since different goals can be accomplished with the "same" modality......they are referred to by what they are being used for.
  - FES-Functional Electrical Stimulation
    - aka-EMS
    - Electrical Muscle Stimulation
  - NMES-Neuromuscular Electrical Stimulation
    - aka-EMS
    - Electrical Muscle Stimulation

Physiology Review

- Neuron
  - Cell body
  - Axon
  - Dendrite

- Types of Neurons
  - A fibers
  - Motor fibers
  - Nociceptors

Primary Afferent Axons

<table>
<thead>
<tr>
<th>Neuron Type</th>
<th>Diameter (μm)</th>
<th>Axon 1</th>
<th>Axon 2</th>
<th>Axon 3</th>
<th>Axon 4</th>
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Types of Nerve Fibers

- A fibers (A Beta)
  - Sensory, motor, fast pain, heat, cold, proprioception, pressure, touch and vibration
  - (mechanoreceptive)

Nociceptors
- Slow and fast pain, temperature excesses, tissue damage

Characteristics of Neurons
- Myelinization
  - Insulation covering the axon, enables more rapid conduction for impulses along the axon
Characteristics of Neurons

- **Diameter**
  - The greater the diameter of the nerve fiber, the more easily the nerve is stimulated and the lower the threshold of excitability to electrical stimulus.
  - Shorter duration of an excitatory response
  - The greater the diameter, the shorter the refractory period

Physiology

- **Neuron Characteristics**
  - Excitability
  - Threshold for Action potential
  - Stimulation Sites
    - Motor Point
      - Muscle belly
        - neuromuscular junction
    - Distal on the muscle belly
      - Longitudinal conduction through the muscle fiber

Nerve Fiber Excitability

- **Propagation of an impulse**
  - The transmission of the electrical information along a nerve fiber
  - Diameter and myelinization of the nerve fiber
  - The stimulus must be of an adequate intensity and duration to meet or exceed the threshold of the nerve fiber
Nerve Fiber Excitability

- Thresholds for nerve are lower than thresholds for muscle that is de-nervated
  - The conduction is poorer
  - Muscle fibers must be stimulated directly
  - Instead of the motor nerve which is unavailable

Refractory Period

- The amount of time that it takes the nerve fiber to return to its pre-stimulus state
- To re-polarize following de-polarization
  - To be able to carry another impulse
  - To continue the sensation or response of the fiber
  - Information may only be transmitted when the nerve fiber re-polarizes

Characteristics of Neurons:

- Excitability
  - Action Potential
    - The "message unit" of the nervous system to transmit information along a nerve fiber
Waveform Considerations

- General Considerations when applying Electrical Stimulation for a motor response
  - Think first...

What purpose does the skin serve?

Skin Stratum Corneum
If you want to accomplish your goal…

- You have to be able to cross over the skin!

Neuromuscular Electrical Stimulation

- NMES
  - Stimulation of the neuromuscular junction for the purpose of eliciting a motor response of the muscle
  - In accomplished whenever there is an electrically induced muscle contraction
    - Requiring that motor points be utilized

Indications for NMES

- Pain relief
- To enhance blood flow
- To fatigue a muscles that are guarding
- To “re-educate” muscle
- To enhance muscle contraction strength and endurance
Types of Motor Responses

- **Twitch**
  - Response to one long duration pulse of electrical stimulus
  - Single motor unit response to stimulus
  - Non-physiological
  - Occurs in response to low frequency stimulus delivery

- **Tetany**
  - The final fusion of muscle twitches
  - Tension is much greater than for individual twitches
  - It is a function of the applied frequency of the electrical stimulus at an amplitude sufficient to elicit a motor response
  - \(35-50\) pps = optimal to limit fatigue

Selective Stimulation Parameters

- **SD Implications**
  - Pulse duration
    - For motor responses of innervated muscle
      - At least 200 usec
  - Intensity
    - For motor responses of innervated muscle,
      - It must be more than just sensory
Selective Stimulation Parameters

- Frequency
  - Less than 15 pps will produce a twitch response
  - More than 15 pps will produce more of a tetanic contraction
    - 35-50 pps for smooth tetanic responses
    - 50+pps will produce a smooth tetanic contraction that will quickly fatigue

NMES for muscle strengthening

- What about ON times?
  - Are they important?
    - Actually the recovery time for the muscle is more important!
  - It can take up to 50 seconds for a muscle to recover after a 10 second maximal contraction

Electrically Induced Muscle Contraction

- Following an electrically induced muscle contraction,
  - Marked increase in the blood flow in the treated extremity
  - Hmmmmm... I wonder what effects that might have?
Electrically Induced Muscle Contraction

- Muscle contractions have been studied in response to different frequencies of ES
  - 8-32 pps significant increase in blood flow (Wakim 1953)
  - Above 32 pps smaller increases in blood flow than 8-32 pps (Wakim, Randall, Imig & Hines 1953)

Direct stimulation of the afferent neurons causes peripheral vasodilation
- Recruitment of muscle fibers will occur in the opposite pattern to voluntary recruitment
  - With ES deeper, slower fatiguing muscles respond first
    - Also fatiguing more quickly
    - In other words, you will not get this, from this...

Physiologic Response
- Lymphatic return
- Blood flow increase
- Strength increase
  - ONLY if
    - Against resistance
    - Exercised to the point of fatigue, etc.
Electrically Induced Muscle Contraction
What about electrical stimulation as an aide to ambulation? After a CVA it has been helpful in alleviating foot drop. Bioness has several products and interesting case histories.

Contraindications to NMES
- Over a pregnant uterus
- In the presence of a pacemaker
- In anesthetic areas
- Transcranially

Hmmm… Why is it contraindicated transcranially?

Contraindications to NMES
- In the presence of a thrombus
  - A blood clot
- In the vicinity of a thrombus
  - These could cause...
Contraindications to NMES

- Unstabilized fracture!!!!!!

So what do you think?
Are you ready to let someone else get your muscles working for you?

Remember that it's a strange but awesome sensation!