Electrical Stimulation

Electrical stimulation is the use of mild electrical pulses through the skin to stimulate muscles and nerves. E-stim is can be used to augment respiratory rehabilitation interventions in order to exercise the neuromuscular junction as well as the muscles. One of the main barriers for patients with a compromised respiratory system is the reduced ability to deliver oxygen to contractile tissues. This inability creates an exercise intolerance, dyspnea, fatigue and disuse. Disuse leads to atrophy, not just muscular atrophy but also neuromuscular junction atrophy.

Review: Efferent/Motor Nerve and Neuromuscular Junction Physiology

Action potential from the brain and spinal cord transmits down motor neuron ↙

Voltage gated calcium channels open, calcium enters neuron terminal ↙

Calcium causes exocytosis of acetylcholine ↙

Acetylcholine binds to receptors that opens muscle fiber channels ↙

Sodium enters muscle fiber, potassium exits muscle fibers ↙

Action potential propagates along sarcolemma causing muscle contraction through actin and myosin bonding

Patients with respiratory dysfunction and decreased oxygen saturation, will have changes to the types of muscle fibers available. There will be a loss of type 1 muscle fibers, which are the muscle fibers with lots of mitochondria and use lots of oxygen and are resistant to fatigue. This leads to a reliance on the quicker to fatigue type 2 muscle fibers, fibers that have less mitochondria and less vascularization. This also likely leads to poor tolerance of therapeutic exercise. Studies indicate that the application of electrical stimulation in addition to usual rehab significantly improves outcomes, including: strength and function.

The use of appropriate electrical stimulation creates an action potential that opens the voltage gated calcium channels of the neuron terminal initiating the cascade of events at the junction and exercising the neuromuscular junction that fires the muscle. Incorporating functional therapeutic movements combining electrical stimulation has shown to be effective.

Recommendations:

- One of the most important factors is the electrode because it is vital to delivering the dose of electrical stimulation to the target tissue that has the desired effect while also overcoming skin resistance.
    - Skin resists electricity, and with poor electrodes the skin can become irritated and even injured.
    - Ensure proper and uniform adhesion on intact skin.
    - Do not use lotions, or over dry flaky skin, or alcohol wipes as they dehydrate the skin.
    - Clean the skin with soap and water
    - Larger electrodes increase patient tolerance and are more likely to stimulate motor points
    - Place electrodes surrounding muscle belly of target muscle
    - Place negative electrode proximal to muscle belly

- Stimulate large muscles – knee extensors, knee flexors, ankle flexors, ankle dorsiflexors, elbow flexors, elbow extensors, wrist flexors, and wrist extensors.
- 50Hz Frequency
- Pulse duration 300 microseconds
- On off duty cycle between 1 /5 and 1/3 ratio. Example 5 seconds on and 25 seconds off
- Use ramp up and ramp down
- Intensity goal is maximum tolerable, this is subjective but the stronger the better, and patient tolerance to likely increase with practice.
- Initial stimulation sessions maybe less likely to see muscle contraction in severe atrophy
- With repetition the neuromuscular junction improves
- Have patient contract with the stimulation if possible and try to combine the contraction with a function activity. Ex. Sit to stand, while stimulating bilateral knee extensors
- Use caution removing the electrode to not damage the skin
- Check the skin

Documentation

- Frequency
- Intensity (intensity may vary day to day)
- Treatment duration
- Tissue treated
- Electrode size and location
- Special settings - on/off setting
- Physiological effect – treatment of muscle atrophy
- Example:
    - NMES to bilateral quadriceps to address atrophy and increase strength and function, 50 Hz and 300 µsec, 2x2 electrodes, channel A and B, 25-30 mA, 15 minutes, 1/5 on off ratio treat muscle atrophy to improve LE function and transfer ability. (note: also add skills of the therapist and pt. response)

References

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5135061/
- https://www.sciencedirect.com/science/article/abs/pii/S0012369215360232

