Creative Evidence-Based Use of Electrical Stimulation in Acquired Brain Injury Rehabilitation

Amy Berryman, OTR, MSHSA
Denise O’Dell, PT, DScPT, NCS, MS
APTA Combined Sections
February 20, 2016
Introductions
adjective: conventional

1) based on or in accordance with what is generally done or believed:
"a conventional morality had dictated behavior"
synonyms: unoriginal · formulaic · predictable · stock · unadventurous · unremarkable
· humdrum · run-of-the-mill

2) (of a person) concerned with what is generally held to be acceptable at the expense of individuality and sincerity.
(of a work of art or literature) following traditional forms and genres:
"conventional love poetry"
synonyms: conservative · traditional · traditionalist · conformist · bourgeois · old-fashioned
· of the old school · small-town · suburban · straight · buttoned-down · square
· stick-in-the-mud · fuddy-duddy
Question:
What is “conventional” E-Stim Use?
Definition

Electrical Stimulation:

The use of electrical current applied through the skin via the motor nerve to help produce a muscle contraction.
Neuromuscular Electrical Stimulation (NMES) vs. Functional Electrical Stimulation (FES)

- **NMES**: uses a device to send electrical impulses to nerves. This input causes muscles to contract. The electrical stimulation can increase strength and range of motion, and offset the effects of disuse. It is often used to “re-train” or “re-educate” a muscle to function and to build strength after a surgery or period of disuse but is more truly routine exercise and strengthening.

- **FES**: refers to the use of (NMES) or electrical stimulation during a task. This can include walking or using an arm to reach. Foot drop is a common problem following a neurological injury which may result in decreased walking speed, decreased step length, and tripping. When FES is applied to the muscles that lift the foot at the correct time during the walking cycle it may not only impact the ability to clear the foot and improve safety when walking but may result in increased strength of those muscles and increased range of motion at the ankle joint. FES can also improve safety, ease, and efficiency with walking.

Berryman and O'Dell 2016

Wikipedia
Learning Objectives

1. Discuss purpose and parameters for use of FES for neuromuscular rehabilitation.

2. Summarize current literature for use of FES for management of impairments.

3. Review clinical cases and videos for creative treatment application of FES.
E Stim Basics: Contraindications/Precautions

- Cardiac Demand Pacemaker - need MD permission
- Hx of Congestive Heart Failure - need MD permission
- Recent Myocardial Infarction - need MD permission
- De-conditioned elderly patients - need MD permission
- Pregnancy (esp. 1st and 3rd trimesters)
- Protruding metal (staples or external fixation)
- Incision sites
- Skin abrasions
- Do not shave the skin sooner than two days before Estim is applied. Use scissors to cut hair.
Peripheral electrical stimulation to induce cortical plasticity: A systematic review of stimulus parameters

Mar2011, Volume 122, Issue 3, Pages 456-463
L.S. Chipchase, S.M. Schabrun, P.W. Hodges

- This review provides an overview of the electrical stimulation parameters needed to induce cortical plasticity in human subjects.
- Current data indicate that stimulation intensity may be an important factor in determining the direction of rapid plastic change. In particular, there was a trend for stimulation above motor threshold to increase excitability of the corticomotor pathway.
- Electrical stimulation in the clinical setting is a feasible and inexpensive application. It has been widely used although its potential for inducing plastic change has been realized only recently.
- How ES can be used to induce clinically meaningful plastic change in movement related disorders needs to be addressed.
E Stim Basics: Parameter Adjustment

Goal of Adjusting Parameters:

1. To achieve the most beneficial and appropriate muscular contraction and in the case of our presentation to achieve function
2. To maintain maximum patient comfort
E Stim Basics: Parameters

Pulse Amplitude (Intensity)
Duration
Pulse Rate (Frequency)
Waveform
E Stim Basics: Pulse Amplitude
E Stim Basics: Duration
E Stim Basics: Pulse Rate
E Stim Basics: Waveform
E Stim Basics: Current Density

• **Smaller electrode**: Greater current density (may be less comfortable, but able to achieve more “robust” contraction if over motor point).

• **Larger electrode**: Lesser current density (may be more comfortable, but will get more “spreading” out of the charge and may not be able to isolate particular muscle group as well).
E Stim Basics: Algorithm for FES Parameter Adjustment

-Candy Tefertiller PT, DPT

- **Estim**
  - On/Off time Ex: 10:10
  - Phase Dep: Switch

- **Frequency** 30-45 Hz
- **Pulse Width** LE’s: 300 ms
  - UE’s: 100-200 ms

- **Contraction thru Full Range?**
  - **YES**
    - ↓ Freq as low as Possible w/ quality contraction
    - If painful, ↑ pulse width to highest comfortable
      Then ↑ freq. up to 35 Hz
  - **NO**
    - Assess available ROM
      And provide AAROM
      Thru full range

- **If no overflow, ↑ pulse width up to 500 ms and**
  - Check for overflow

- **If overflow, ↓ pulse 100 ms, ↑ Freq up to 35 Hz & ↑ amp to tetany**

- **If not painful, ↑ pulse width up to 35 Hz &**
  - Check for overflow
E-Stim Basics: Dosage
Principles to Enhance Neural Plasticity

- Use it or Lose it
- Use it and Improve it
- Specificity Matters
- Repetition Matters
- Intensity Matters
- Time Matters
- Salience Matters
- Age Matters
- Transference
- Interference

*Kleim & Jones 2008; Hornby et al 2011*
E-stim Basics: Preparatory Methods

To optimize the quality of practice:

Overall Treatment Planning

• **Evaluate and adjust for/treat:**
  ROM, Spasticity, Sensation

• **Manage spasticity**
  – Tone reduction techniques,
    meds, splinting/casting

• **Postural interventions**

• **Assess Learning needs/best environment for practice**
E-stim Basics: Preparatory Methods

To optimize the quality of practice:

Immediately before FES Practice

• **Prepare ROM**
  – Stretching, PROM/AROM activities

• **Reduce Spasticity**
  – Weightbearing, closed chain/modified closed chain, heat/ice

• **Adjust posture to match the task**
  – Consider props or other tools

• **Adjust to learning needs of patient**

Berryman and O’Dell 2016
UnconINTERVENTIONS:

1. Muscle activation
2. Sensory awareness
3. Co-contraction
4. Paired with robotics

Berryman and O’Dell 2016
Muscle Activation

Berryman and O'Dell 2016
Facilitating weight shift

Berryman and O'Dell 2016

24
Parameters Used

• **Placement:** right glutes
• **Pulse Rate:** 35 pps
• **Pulse Width:** 350 microseconds
• **Waveform:** Symmetrical
• **Cycle:** N/A: Single Channel
• **Amplitude:** To motor contraction
• **Timing Characteristics:** Left heel switch
Facilitating weight shift while walking

• Case example:
  • 26 yo male, s/p brain tumor rupture, 6 mos post injury (outpatient)
  • L hemiparesis with severe loss of sensation/proprrioception
Facilitating weight shift
Parameters Used

- **Placement**: left tricep, left lower trapezius
- **Pulse Rate**: 35 pps
- **Pulse Width**: 350 microseconds
- **Waveform**: Asymmetrical
- **Cycle**: Simultaneous
- **Amplitude**: To motor contraction
- **Timing Characteristics**: 20 seconds on, 2 seconds off with 2 second ramp time
Facilitating weight shift

- 45 yo female, s/p CVA with right hemiparesis, severe inattention and proprioceptive loss, 1 yr post injury (outpatient)
Parameters Used

- **Placement:** right triceps and right wrist extensors
- **Pulse Rate:** 35 pps
- **Pulse Width:** 350 microseconds
- **Waveform:** Symmetrical
- **Cycle:** Simultaneous
- **Amplitude:** To muscle contraction
- **Timing Characteristics:** Heel switch under left (uninvolved) foot, when pt shifts weight to involved side, estim is triggered to the right triceps and wrist extensors to stabilize lettuce while cutting

Berryman and O'Dell 2016
Shoulder Subluxation
Parameters Used

- **Placement:** right supraspinatus, anterior deltoid, infraspinatus, and middle deltoid
- **Pulse Rate:** 35 pps
- **Pulse Width:** 350 microseconds
- **Waveform:** Symmetrical
- **Cycle:** Simultaneous
- **Amplitude:** To muscle contraction
- **Timing Characteristics:** Used either 1:1 or 1:2 ratio, example 10 on, 10 off or 10 on, 20 off
Functional Activity: Wheelchair Propulsion
Parameters Used

• **Placement:** left wrist extensors and triceps
• **Pulse Rate:** 50 pps (for comfort)
• **Pulse Width:** 300 microseconds
• **Waveform:** Asymmetrical
• **Cycle:** Simultaneous
• **Amplitude:** To muscle contraction
• **Timing Characteristics:** Hand switch to time with activity

Berryman and O'Dell 2016
Functional Activity: Handwriting
Lip Closure for Swallowing

• 30s male, s/p TBI, 1 yr post injury (outpatient)
• Goal is to close lips while swallowing, stop drooling
Parameters Used

- **Placement:** Orbicularis oris
- **Pulse Rate:** *
- **Pulse Width:** *
- **Waveform:** *
- **Cycle:** Simultaneous
- **Amplitude:** To muscle contraction
- **Timing Characteristics:** 12 seconds on, 8 seconds off

*Used parameters in the Vital Stim manual, co-tx with speech therapist to set up home estim unit*
Using orthosis to keep fingers straight while working on wrist extension (pts fingers were curling, negatively reinforcing a “tenodesis” effect, which could increase flexor tightness)

Using buddy strapping to positively reinforce appropriate grasp pattern with e-stim on wrist/finger flexors
Wrist/finger extension practice, note the bending of middle finger

Wrist/finger extension practice, taping to middle finger to assist with full extension
Sensory level stim as a treatment option:

• Sensory level stim can be more beneficial than none

• Sensory level stim can improve hand/arm kinematics

• Sensory level stim on the arm can improve visual inattention

• Sensory level stim can improve arousal in disorders of consciousness
• Discussion on parameters for sensory

Look at NRN ???

High rate, low width -- Amy

35 rate – traditional pulse to point of muscle contraction and back off.

Lower – would that trigger more awareness?
Sensory Awareness

• Case example:
  – 33 yo male s/p TBI, 1 year post injury, at Craig for 1 week re-evaluation, resolving right hemiparesis
  – Has full active range of motion and can reach in all planes against gravity, abnormal proprioception in right hand
  – Goal: increase right UE coordination
Sensory Awareness
Parameters Used

- **Placement:** Channel 1: Posterior forearm and back of hand, Channel 2: Anterior forearm
- **Pulse Rate:** 65 pps
- **Pulse Width:** 250 microseconds
- **Waveform:** asymmetrical
- **Cycle:** simultaneous
- **Amplitude:** sensory level only
- **Timing Characteristics:** 20 seconds on, 2 seconds off, with 2 second ramp
Sensory Awareness – BITS
Parameters Used

• **Placement:** left forearm (2 channels) OR left wrist extensors and left scapula stabilizers
• **Pulse Rate:** 50 pps
• **Pulse Width:** 300 microseconds
• **Waveform:** symmetrical
• **Cycle:** simultaneous
• **Amplitude:** sensory level only, pt unable to feel so took it to motor and went right below motor threshold
• **Timing Characteristics:** Continuous for the task
Sensory Awareness - Vision
Parameters Used

- **Placement:** Right/left cheek OR right/left upper neck and back
- **Pulse Rate:** 80 pps
- **Pulse Width:** 250 microseconds
- **Waveform:** asymmetrical
- **Cycle:** alternating
- **Amplitude:** sensory level only
- **Timing Characteristics:** 2-5 seconds alternating
Sensory Awareness: “Neglect”
Parameters Used

- **Placement:** Left arm
- **Pulse Rate:** 50 pps
- **Pulse Width:** 250 microseconds
- **Waveform:** symmetrical
- **Cycle:** simultaneous
- **Amplitude:** sensory level and/or motor level
- **Timing Characteristics:** 20 seconds on, 2 seconds off, 2 seconds ramp
Comparing Sensory Parameters
Co-contraction in Ataxia

Reference: Neuromuscular electrical stimulation of the median nerve facilitates low motor cortex excitability in patients with spinocerebellar ataxia.

Case Example
2 years s/p GSW
Trunk & Limb Ataxia
Goal – Sustained upright posture for balance & function
Co-Contraction in Ataxia
Co-Contraction in Ataxia

Estim coming off

Estim turning on and sustained
Sit to Stand in Ataxia

No estim and left lean

4 channels estim on trunk, note upright head and posture
STANDING Ataxia

No estim and left lean

4 channels estim on trunk, note upright head and posture
Parameters Used

- **Placement:** 2 estim units: abs and erectors
- **Pulse Rate:** 35 pps
- **Pulse Width:** 350 microseconds
- **Waveform:** Symmetrical
- **Cycle:** Simultaneous
- **Amplitude:** To motor contraction
- **Timing Characteristics:** With hand switch to time with task
Sit to Stand in Ataxia: 1 year later
Parameters Used

- **Placement:** 2 estim units: left abs and erectors, left glutes
- **Pulse Rate:** 35 pps
- **Pulse Width:** 350 microseconds
- **Waveform:** Symmetrical
- **Cycle:** Simultaneous
- **Amplitude:** To motor contraction
- **Timing Characteristics:** With hand switch to time with task

Berryman and O'Dell 2016
FES Bike: RT300
Alter G with Bioness

Case Example:

• Alter G
  – Body weight support treadmill

• Bioness – with foot sensor
  – L300 (anterior tib / peroneal stim)
  – L300 plus (hamstring for this case – can be quads)

• 44 year old male, 6 months s/p L CVA, right hemiparesis with apraxia

Berryman and O’Dell 2016
Alter G with Bioness
Erigo
Armeo Power

- Inpatient Rehab s/p CVA
- Flaccid Right UE with sublux
- Estim at sensory level
- Full robotic assist with augmentative feedback using ARMEO
Future Applications

SAGE 6 channels per unit - simultaneous stim for all channels
Future Goal is remote and patterned
Translation Into Your Practice

• Low cost options for home and clinic use

• Patient and family independent in use to maximize neuroplasticity

• Remember to integrate neuroplasticity principles and appropriate preparatory methods
Translation into your Practice
Questions/Discussion
References


