

# FES and Similar Approaches



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## Objectives

1. To understand the basics of FES  
– Choosing appropriate clients, goals & parameters
2. To review the literature on FES & stroke
3. To become familiar with FES systems for stroke

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## Outline

### First Hour

1. Review of FES basics ~15 min
  2. FES for Upper Extremity ~15 min
  3. FES for Lower Extremity ~15 min
- \*\*\*Break\*\*\* ~5-10 min

### Second Hour

FES stations  
Bioness, WalkAide, Odstock

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## Review of FES Basics

Functional electrical stimulation is the use of ES as..?

- A. An orthotic substitute for a muscle function
- B. A means to prevent learned non-use
- C. A tool for motor relearning
- D. A, B & C

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## Review of FES Basics

Which of the following is false regarding ES muscle contractions?

- A. Recruit a small number of motor units
- B. Motor units fire synchronously
- C. Large, fast fatigable units fire first
- D. More resistant to fatigue than physiologic contractions

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## Review of FES Basics

Increasing which parameter(s) will increase the strength of an ES contraction?

- A. Pulse duration
- B. Frequency
- C. Intensity/amplitude
- D. A & C

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## Review of FES Basics

If stimulating a small muscle, the best response is obtained by..?

- A. Placing cathode on motor point, using asymmetric waveform
- B. Placing cathode on motor point, using symmetric waveform
- C. Placing anode on motor point, using asymmetric waveform
- D. Placing anode on motor point, using symmetric waveform

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## Review of FES Basics

Research supports which parameter as the most important for achieving success with ES?

- A. Duration of treatment
- B. Waveform
- C. Intensity/amplitude
- D. Active participation of client

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## Review of FES Basics

Which stroke client is a good candidate for FES of the UE?

- A. Peripheral nerve damage in UE
- B. No AROM in UE
- C. Pacemaker implanted
- D. Impaired sensation in UE, some AROM

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# Hemiplegic Shoulder

## Snels et al. 2002

- Methodological quality of reviewed studies moderate to poor
- Concluded that FES was 1 of the 2 most promising methods for treatment of hemiplegic shoulder pain

## Van Peppen et al. 2004

- Strong evidence found for increasing PROM & reducing caudal subluxation with FES
- Insufficient evidence found for reducing pain with FES

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# Hemiplegic Shoulder

- Early post-stroke: FES is efficacious for **preventing subluxation** & increasing UE function
- Chronic stroke: FES is efficacious for **reducing pain**  
(Chantraine et al. 1999; Linn et al. 1999; Ada & Foongchomcheay 2002)
- FES for hemiplegic shoulder does not improve UE function (Church et al. 2006, Price & Pandyan 2001)

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# Hemiplegic Shoulder

Goal – joint protection (early)  
pain reduction (late)

- Parameters – **endurance**
- Posterior deltoid and supraspinatus (Baker and Parker 1986, Kobayashi et al. 1999)
  - Use minimum amplitude needed to raise humeral head into glenoid fossa



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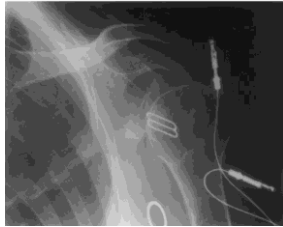
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# Hemiplegic Shoulder

Subluxed Shoulder



Subluxed Shoulder with FES



(Linn et al. 1999)

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# Hemiplegic Shoulder

## FES Prescription (Linn et al. 1999)

- 4X/day with >2 hrs between sessions
- Session length = 30 min wk 1, 45 min wk 2&3, 60 min wk 4
- Asymmetrical biphasic waveform
- Pulse width = 300µs
- Frequency = 30Hz
- On time 15 sec (including ramp up/down of 3/3)
- Off time 15 sec

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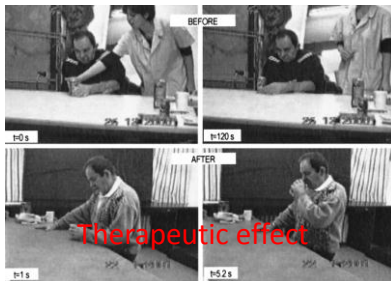
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# FES in UE

## Popović et al. 2002



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## FES in UE

Sullivan & Hedman 2004, 2007



**Figure 1.** The patient used a hand switch to activate neuromuscular electrical stimulation while lifting a 250-mL can.

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- Combined sensory & motor ES for a home program
- Practice of functional activities
- Hand switch to trigger ES

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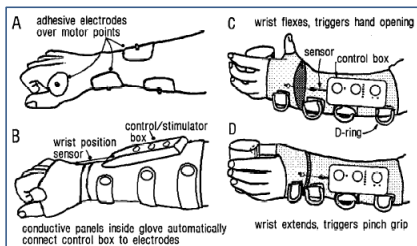
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## The Bionic Glove

- Electronically senses voluntary wrist movements & provides ES to finger & thumb muscles to produce grasp & release

(Prochazka et al. 1997, Popović et al. 1999)



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## The ReJoyce: In-Home Tele-Rehabilitation + FES

Kowalczewski et al. (under review *NeuroRehabil Neural Repair*)



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## FES for Gait

- Appropriate for clients with some walking ability
- Treatment tailored to client & his/her deficits

### Wieler et al. 1999

- For foot drop:
  - ES to peroneal nerve to elicit ankle dorsiflexion
  - If dorsiflexion not sufficient, stim increased to elicit flexor reflex
- For knee or ankle instability during stance:
  - Add ES to quads or tibial nerve
- For instability of hip/pelvis:
  - Add ES of gluteus medius

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## FES for Gait – What is the evidence?

FES ↑ walking speed (Laufer et al. 2009, Wieler et al. 1999)

- Kottink et al. 2004 – Systematic review
  - 5/6 studies showed positive effect of FES on walking speed
- Robbins et al. 2006 – Meta-analysis
  - FES has therapeutic effect on speed in subjects post-stroke

FES ↑ muscle strength

- Glanz et al. 1996 – Meta-analysis
  - FES promotes recovery of muscle strength after stroke

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## FES for Foot Drop

- 1<sup>st</sup> functional application in neuro condition (Liberson et al. 1961)
- Target tibialis anterior
- External trigger

#1: Cathode over TA



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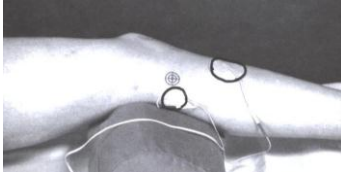
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## FES for Foot Drop

- 1<sup>st</sup> functional application in neuro condition  
(Liberson et al. 1961)
- Target tibialis anterior
- External trigger

#1: Cathode over CPN



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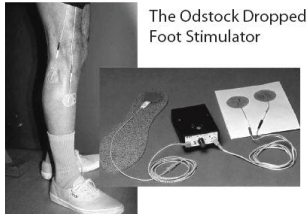
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## Odstock Dropped Foot Stimulator

- Single channel
- Synchronised to gait with foot switch
- Odstock sounder – useful for therapist



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## ODFS – What is the evidence?

### Clinical

- Successfully treated >6000 pts in UK
- Compliance after 1 yr: 92% in MS. 86% in CVA

(FES: Applications in Rehabilitation 2007)

### Research

ODFS ↓ effort of walking (Taylor et al. 1999)

- 151 subjects with upper motor neuron lesions who had used ODFS for 4.5 months
- Saw 31% reduction in Physiological Cost Index (PCI) of walking
- PCI = change in HR from resting to steady speed of walking  
walking speed

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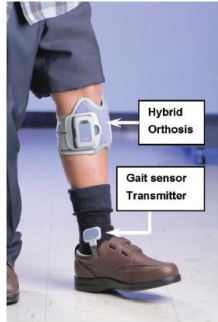
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## NESS L300

- Stim to CPN & TA
- Triggered by force sensor under foot
- Wireless



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## NESS L300 – What is the evidence?

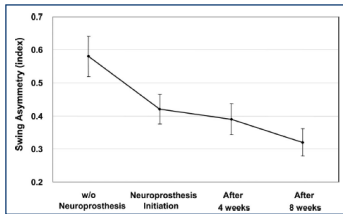
Hausdorff & Ring 2008

Chronic hemiparesis

n=24

↑ daily use from 1 hr/day to full day in 4 wks

↑ gait symmetry



Orthotic effect

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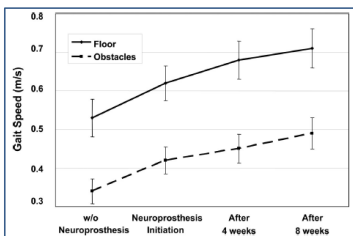
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## NESS L300 – What is the evidence?

↑ gait speed (Hausdorff & Ring 2008)

- Over-ground & negotiating obstacle course



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# NESS L300 – What is the evidence?

Laufer et al. 2009

16 chronic stroke users followed for 1 year

	2 mos	1 yr
Participation domain (Stroke Impact Scale)	25.2%↑	36.7%↑
Gait speed (10mWT)	29.2%↑	58.2%↑

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## WalkAide



- Single channel (CPN)
- Leadless
- Single-handed application
- Built-in accelerometer (tilt sensor)
  - ES on in late stance when lower leg is behind body (tilted back) & off at beginning of next stance when lower leg is in front of body (tilted forward)

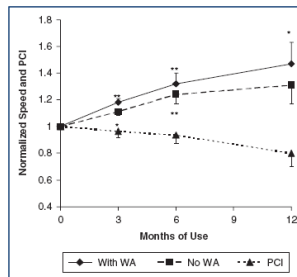
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## WalkAide – What is the evidence?

Stein et al. 2006

- ↑ walking speed
- ↓ effort of walking



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## What causes a 'therapeutic' effect?

- Increased strength, coordination & conditioning  
(Wieler et al. 1999)
- Improved motor unit recruitment  
(Newsam & Baker 2004)
- Corticospinal connections strengthened with 3-12 months of WalkAide use (Everaert et al. 2010)
- Increased cortical activation after 8 wk FES program for hemiparetic wrist & hand (Page et al. 2010)

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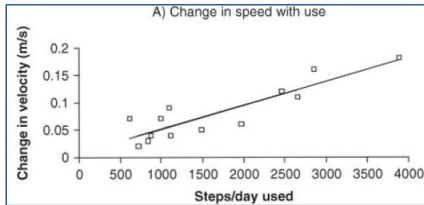
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## Increasing Intensity

- ↑ in speed correlated with amount of WalkAide use (Stein et al. 2006)



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