

## Functional Electrical Stimulation (FES): Gait and Exercise Activities

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## Physical Activity in SCI

- Few persons with SCI meet recommended standards
- Advances in wheelchair technology decrease physiological stresses
- Limited opportunities for exercise activities

## Complications of SCI

- Osteoporosis
- Urinary tract infections
- Muscular atrophy
- Vascular atrophy
- Pressure ulcers
- Spasticity

## Risk Factors

- Obesity
- Hypertension
- Blood lipid profiles
- Insulin response
- Hemostatic factors

## Secondary Disabilities

- Coronary heart disease
- Stroke
- Diabetes

## Functional Electrical Stimulation

“ a replacement electrotherapy applied in patients with a central nervous system lesion, so that at the very time of stimulation, the muscle contraction has a functional purpose either in locomotion or in prehension or in other muscle functions” (Lieberson, 1961)

## Functional Electrical Stimulation

May provide a means to:

- 1) Enable those with SCI to perform functional tasks
- 2) Enable those with SCI to perform exercise activities
- 3) Evaluate and prepare candidates for implanted technologies

## Modes of FES

- Electrically-assisted knee extension
- Electrically-stimulated cycle ergometry (ESCE)
- Electrically-stimulated ambulation (ESA)

## Electrically-Assisted Knee Extension

- Increased exercise capacity
- Increased force and endurance, 50-64% (Rodgers, 1991; Rabishong, 1992)
- Increased lower extremity mass - up to 27% (Pacy, 1987, Dudley, 1999)



## Electrically-Assisted Cycling:



- Participant Selection
  - Persons with SCI (C<sub>4</sub>-T<sub>11</sub>)
  - Medically stable
  - Effective response to electrical stimulation
  - Sensory tolerance to electrical stimulation

## Electrically-Assisted Gait:



- Participant Selection
  - Persons with SCI (C<sub>6</sub>-T<sub>12</sub>) ? (T<sub>4</sub>-T<sub>11</sub>)
  - Medically stable
  - Effective response to electrical stimulation
  - Sensory tolerance to electrical stimulation

## Exercise Performance

- ☞ Increased exercise performance (time to fatigue)
- ☞ Increased muscle force
- ☞ ESA – Increased time, distance, pace of ambulation (Klose, 1996; Jacobs, 1998)

### Complications of SCI

- Osteoporosis
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### Osteoporosis

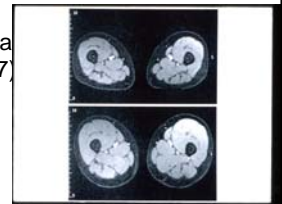
- Equivocal findings
- ESCE & ESA – No change in bone density in chronic SCI (Leeds, 1990; Bodell, 1996; Needham, 1997)
- ESCE – Decreased rate of bone loss as compared with regression analysis of historical data (Rodgers, 1991, Hamgartner, 1994)

### Lower Extremity Joint Integrity

- ESCE – Less damage to knees and femoral head than controls (Nash, 1994)
- ESA – Significant reduction in knee abnormalities post-ESA training (Betz, 1996)

### Lower Extremity Muscle Mass

- Significantly increases lower extremity mass
- ESCE – Approx 10% gains in quadricep area (Sloan, 1994)
- ESA – Approx 25% gain in quadricep volume (Jacobs, 1997)



### Spasticity

- Temporary reduction in spasticity during the fatigued state
- Severity of spasms may increase with training

### Lower Extremity Circulation

- ESCE – Increased cross sectional area (CSA) and flow through the common femoral artery (Nash, 1996)
- ESA – Increased CSA and blood flow (Nash, 1997)
- ESA – Increased vascular capacity (Jacobs, 1999)

### Cardiac Adaptations

- ESCE - Increased left ventricular mass in trained tetraplegics (Danopoulos, 1986; Nash, 1991)

### Cardiovascular Fitness

- ESCE - Decreased resting heart rate with increased resting stroke volume (Faghri, 1992; Petrofsky, 1992)
- ESA - Improved upper extremity work capacity (Jacobs, 1997)
- ESA - Enhanced central hemodynamics (Jacobs, 1998)

### Immune Function

- ESCE – Increased number, percentage, and cytotoxic activity of natural killer cells (Nash, 1994)

### Psychological Benefits

- ESCE – Improved self-concept (Sipski, 1989); Decreased depression (Twist, 1992)
- ESA – Significantly improved self-concept with decreased depression scores (Guest, 1997)

### Motor/Sensory Effects of FES

- Limited evidence
- Single subject study (McDonald, 2003)

### Training Benefits

- Increased volume of muscle mass in paralyzed lower extremities
- Increased size of and flow through circulatory system within the lower extremities
- Increased upper extremity work capacity
- Enhanced central hemodynamics
- Positive psychological changes