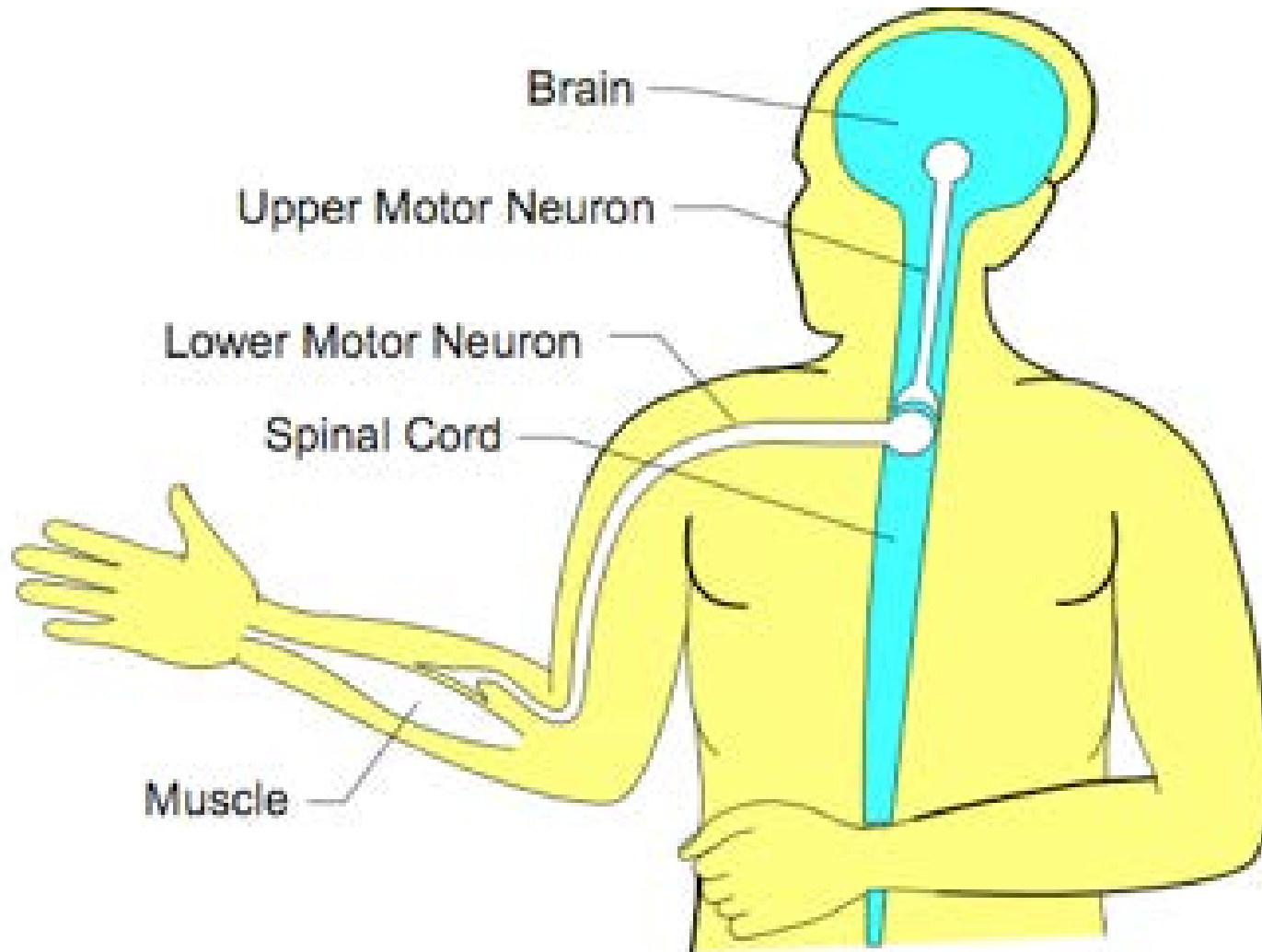


ELEC ENG 3BB3:
Cellular Bioelectricity

Notes for Lecture 30
Tuesday, April 1, 2014

Normal Functional Control



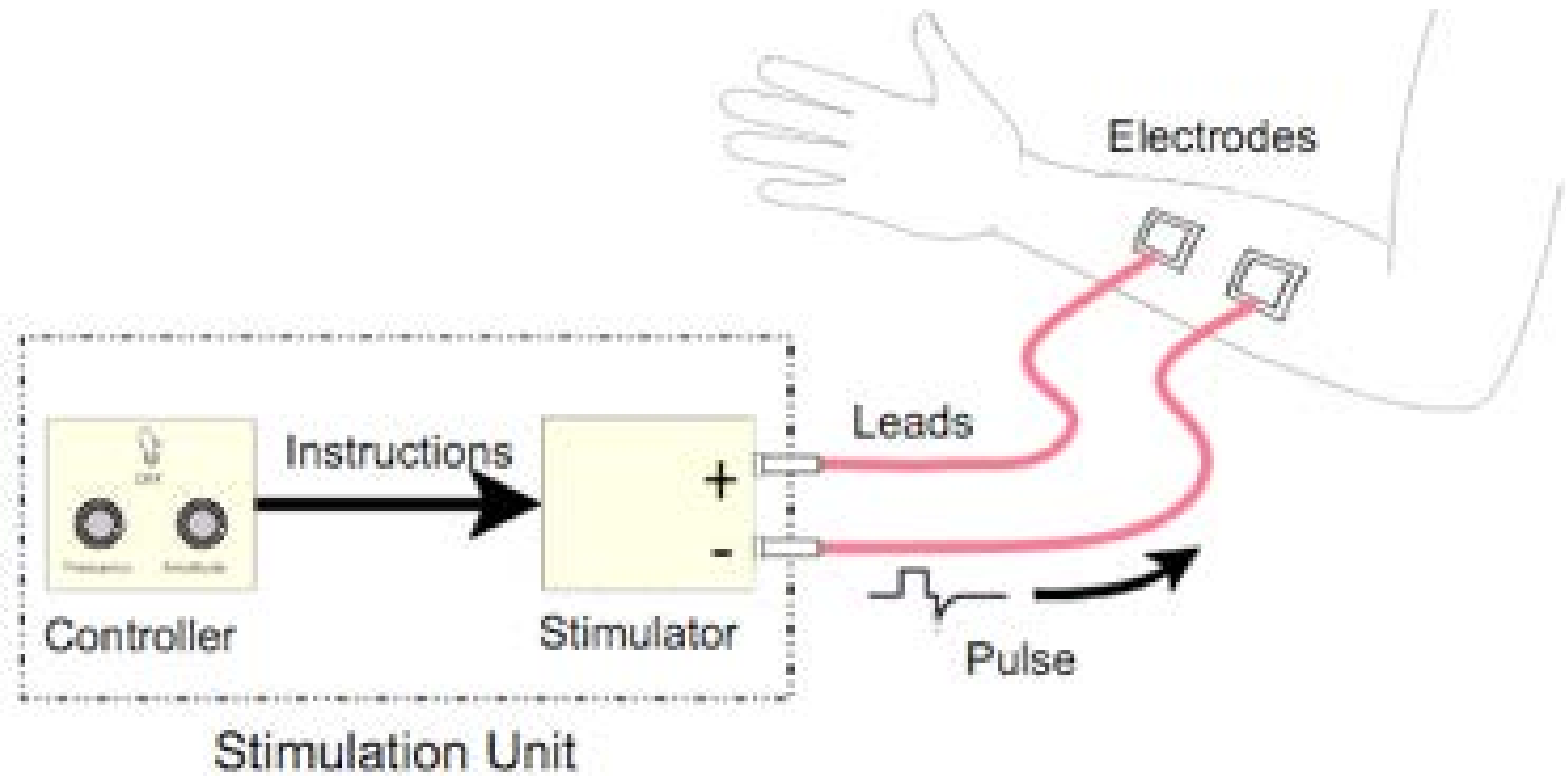
Current uses of FES

- Breathing assist
- Grasping and Reaching
- Transfer and Standing
- Stepping and Walking
- Bladder and Bowel function

FES System

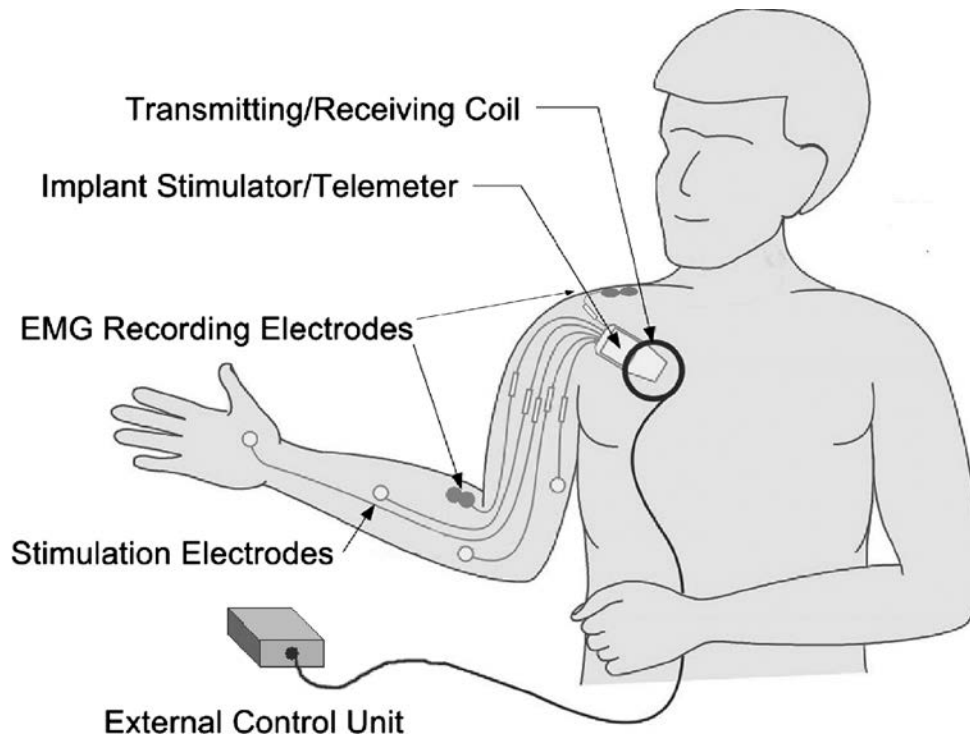
- Controller
- Pulse Train Generator
- Electrode leads
- Electrodes
- Feedback?

FES System (cont'd)



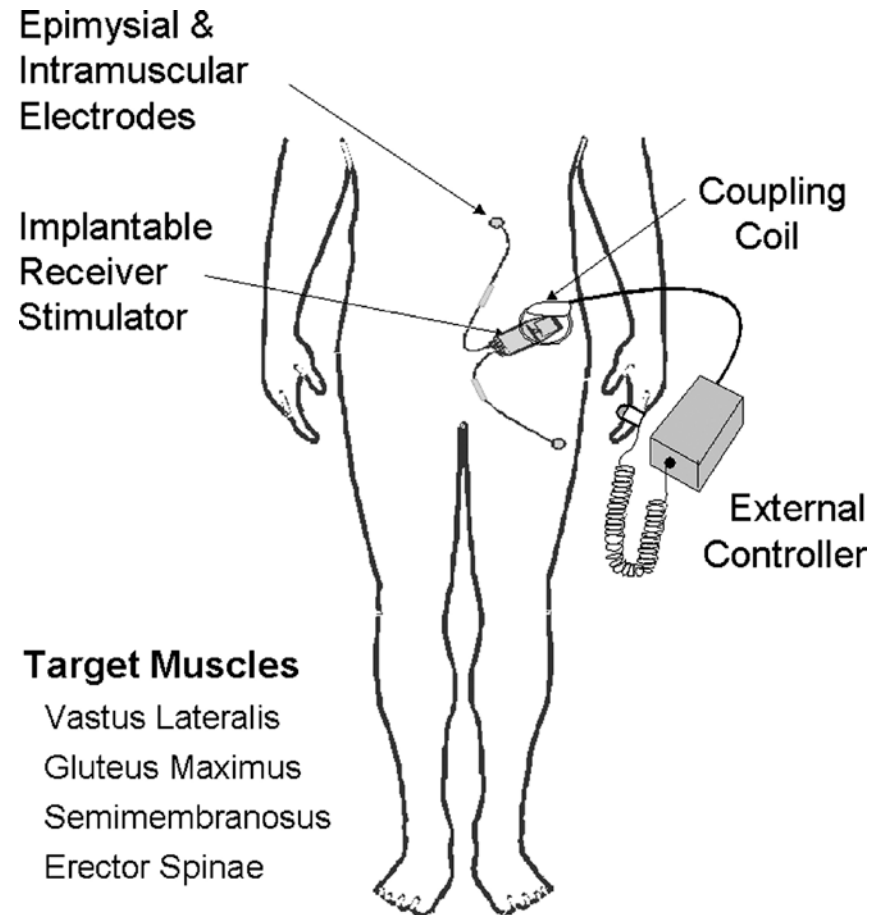
Upper limb stimulation:

- Stimulates peripheral nerve fibers of motor neurons
- Used in spinal cord injury or stroke patients



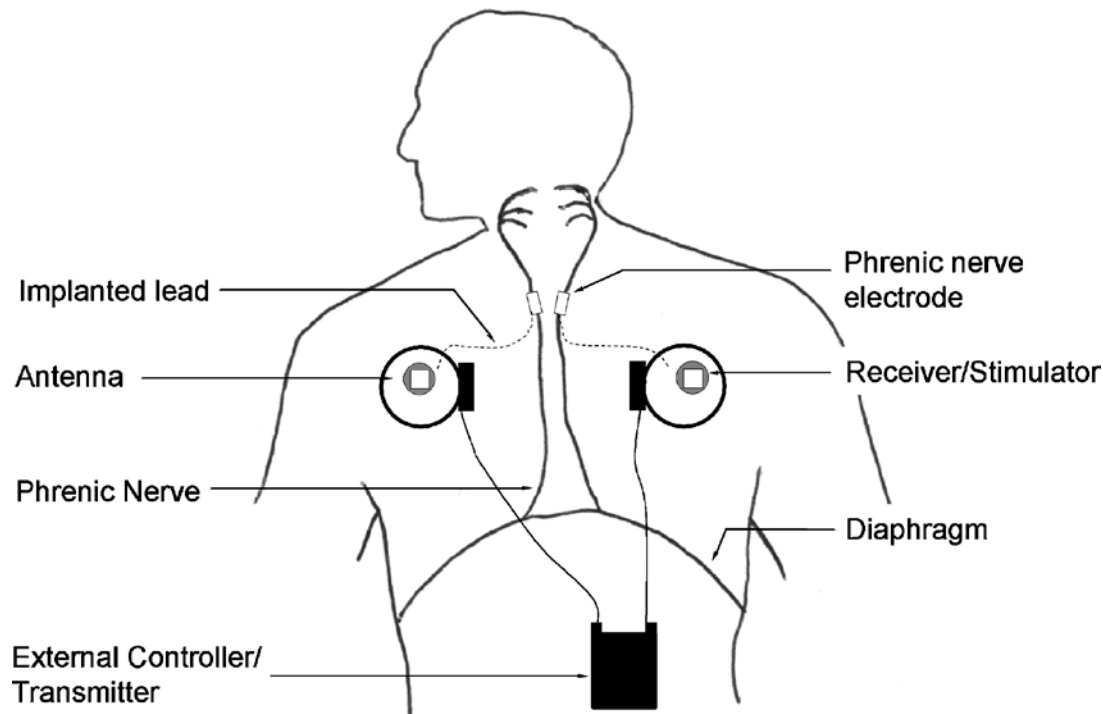
Lower limb stimulation:

- Footdrop control
- Standing control



Phrenic nerve stimulator:

- Provides diaphragm pacing to aid respiration
- Bilateral stimulation for symmetrical activation of the diaphragm

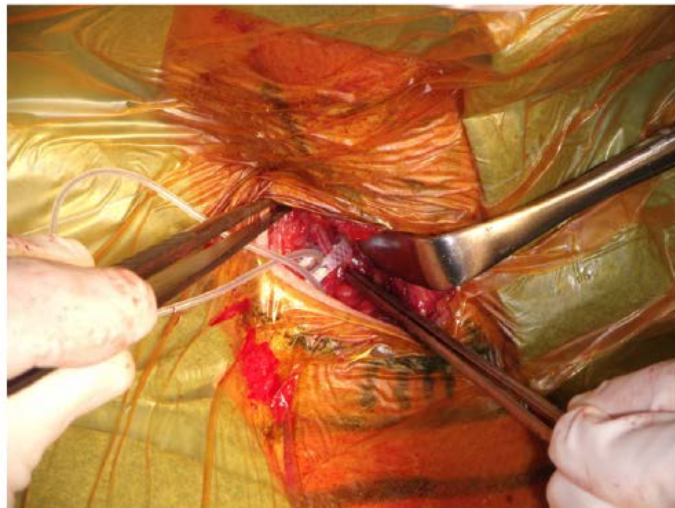


Surgical Attachment

a



b



Respiratory Assist – Diaphragm Pacing

- More than 12,000 spinal cord injuries in U.S. annually
- >500 need mechanical ventilation (high quadriplegics)
- Does pacing diaphragm interfere with cardiac pacing? No
- Overall system same as phrenic

Electrode Position (Motor Point)

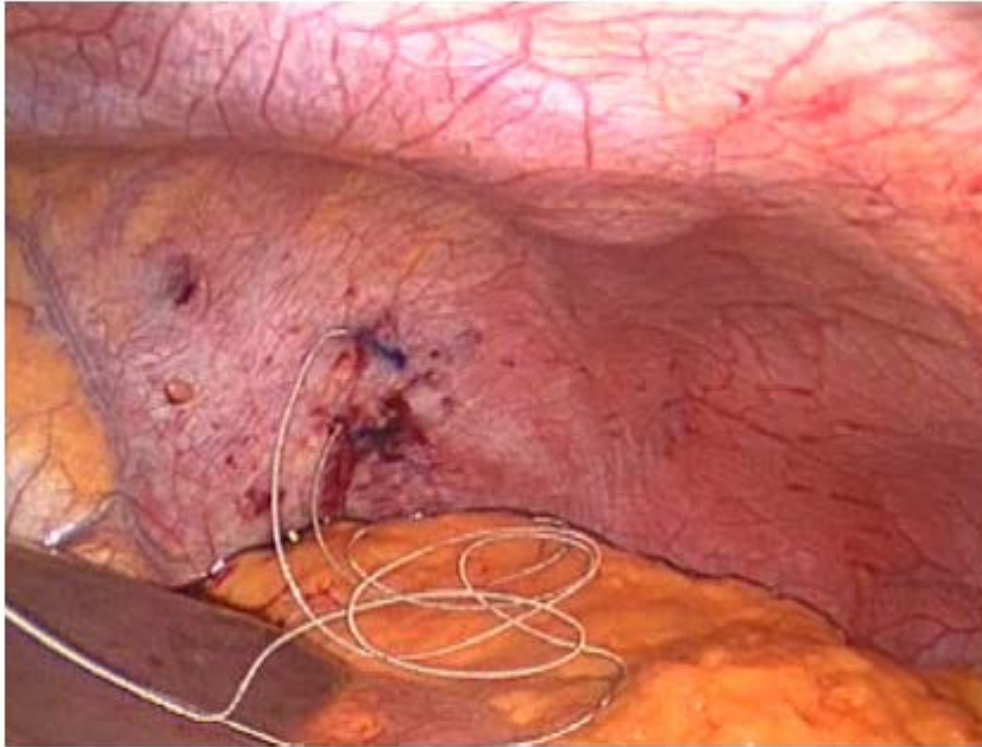


Fig 1. Two electrodes have been placed in the left diaphragm at the motor point, which is lateral to the pericardium. Mapping identified the motor point, which is marked on the diaphragm.

Results of Stimulation

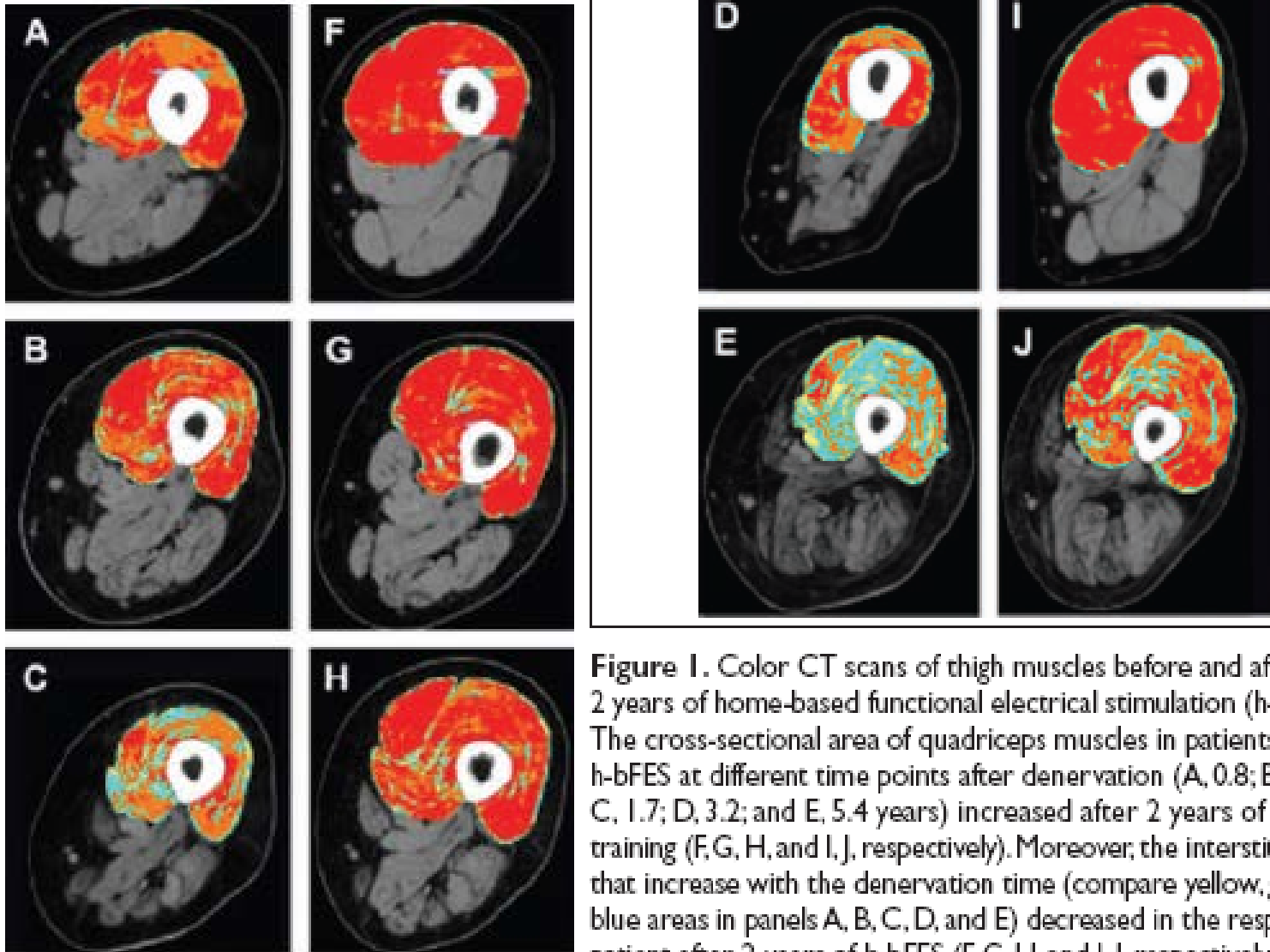


Figure 1. Color CT scans of thigh muscles before and after 2 years of home-based functional electrical stimulation (h-bFES). The cross-sectional area of quadriceps muscles in patients starting h-bFES at different time points after denervation (A, 0.8; B, 1.2; C, 1.7; D, 3.2; and E, 5.4 years) increased after 2 years of home training (F, G, H, and I, respectively). Moreover, the interstitial tissues that increase with the denervation time (compare yellow, green, and blue areas in panels A, B, C, D, and E) decreased in the respective patient after 2 years of h-bFES (F, G, H, and I, respectively)

Histology Results

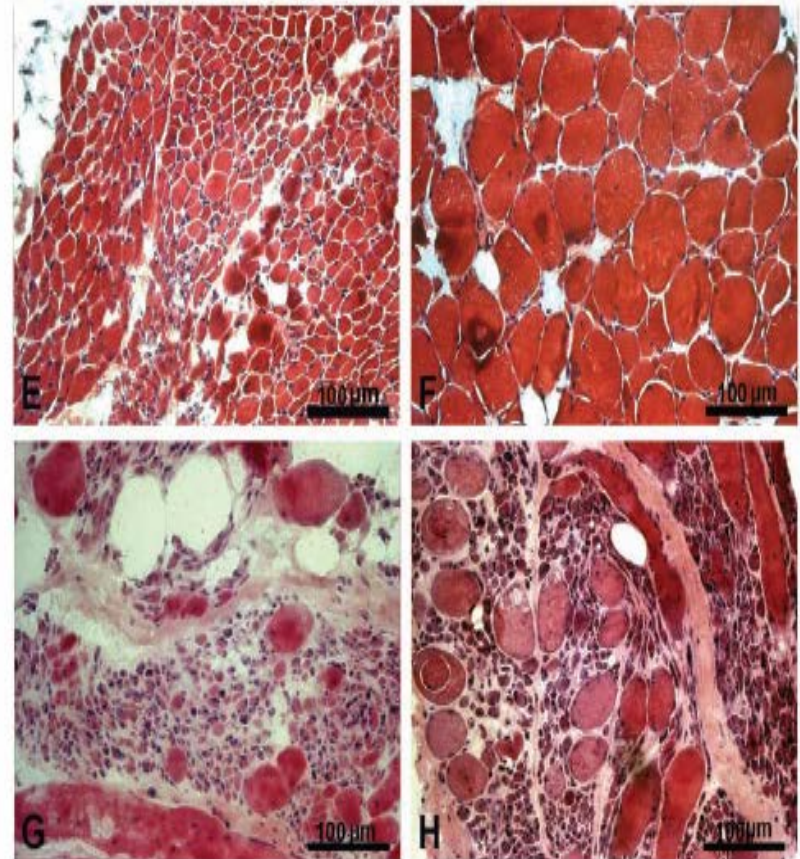
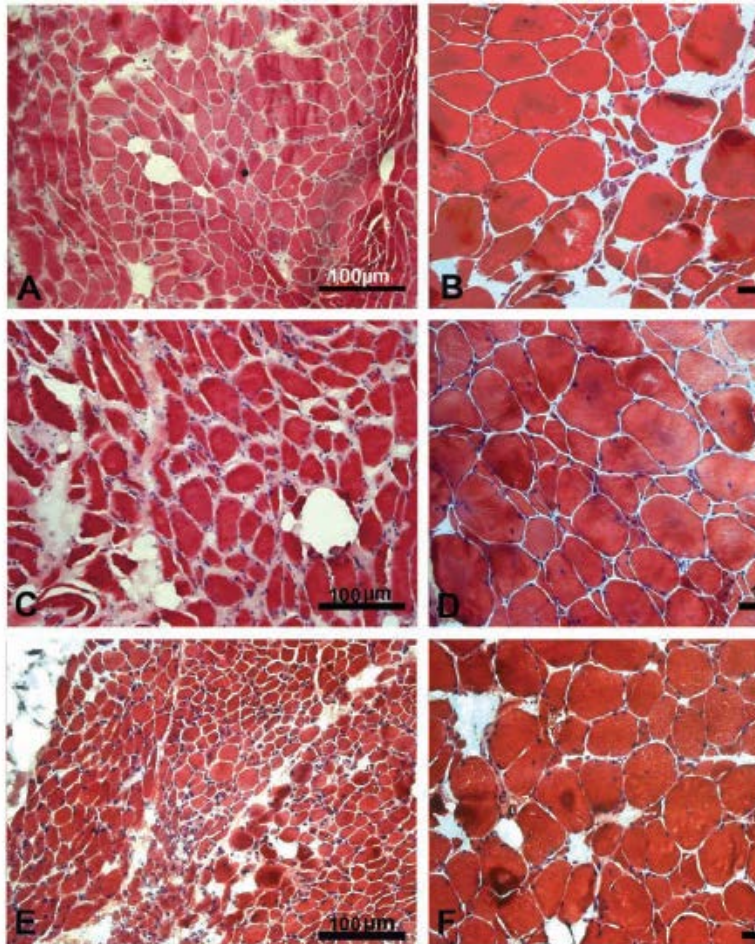
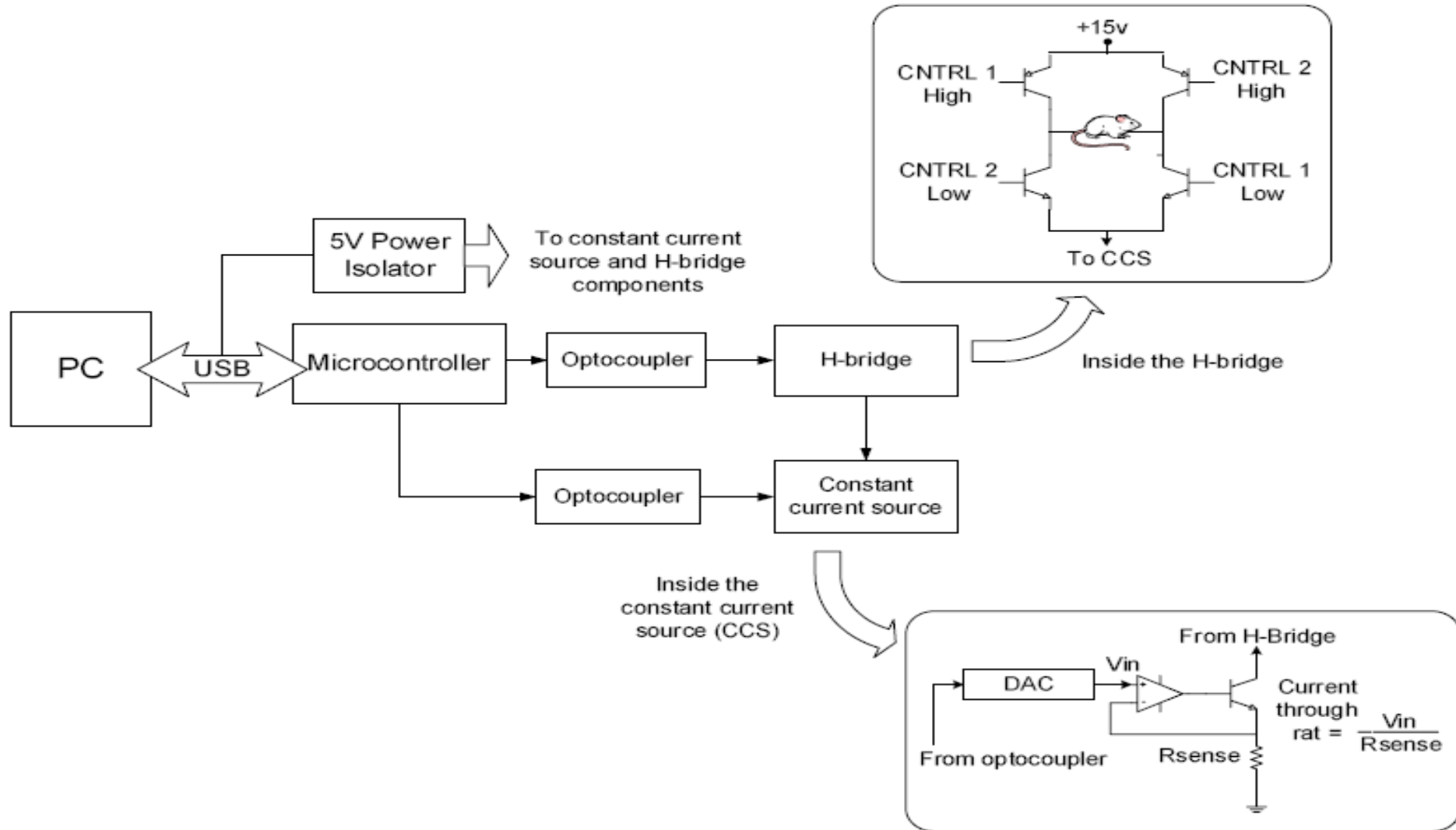


Figure 4. Lower motor neuron (LMN) denervated human muscles recover from atrophy after 2 years of home-based functional electrical stimulation (h-bFES). Hematoxylin and eosin staining of muscle biopsies harvested from vastus lateralis of LMN paraplegic patients before (A, C, E, G) and after (B, D, F, H) 2 years of h-bFES. When started earlier than 2 years after LMN lesion, the h-bFES treatment increases muscle fibers to healthy innervated values; however, with a later start of h-bFES, muscle biopsies show only some large muscle fibers and adipose and fibrous connective tissue do not fully regress

Basic Study to Determine Effects

- Stimulate rat gastrocnemius with 200 μ sec biphasic pulses at 100 Hz for 400 ms bursts separated by 6 sec rest for 1 hour/day for 5 days over 1 month after denervation
- Measure histology and functional outcomes at end

Instrumentation



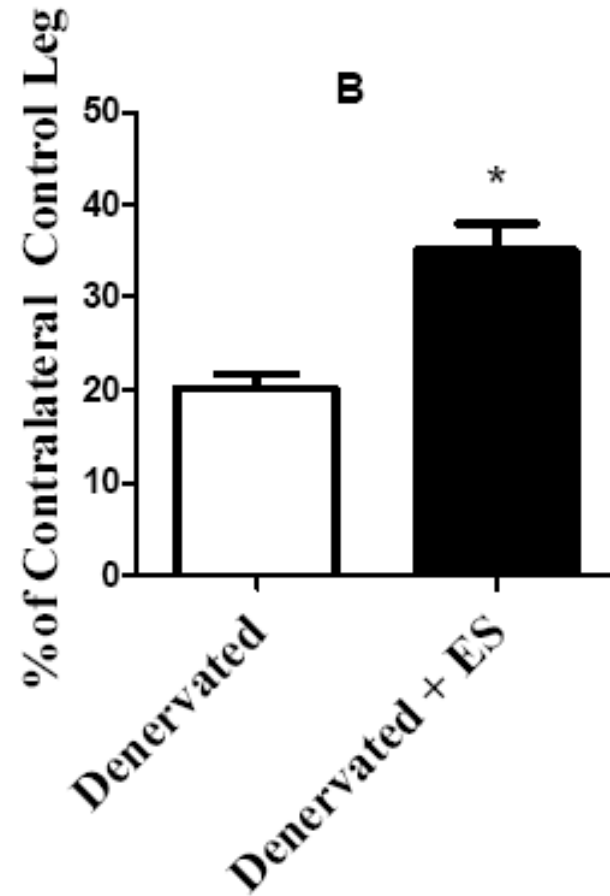
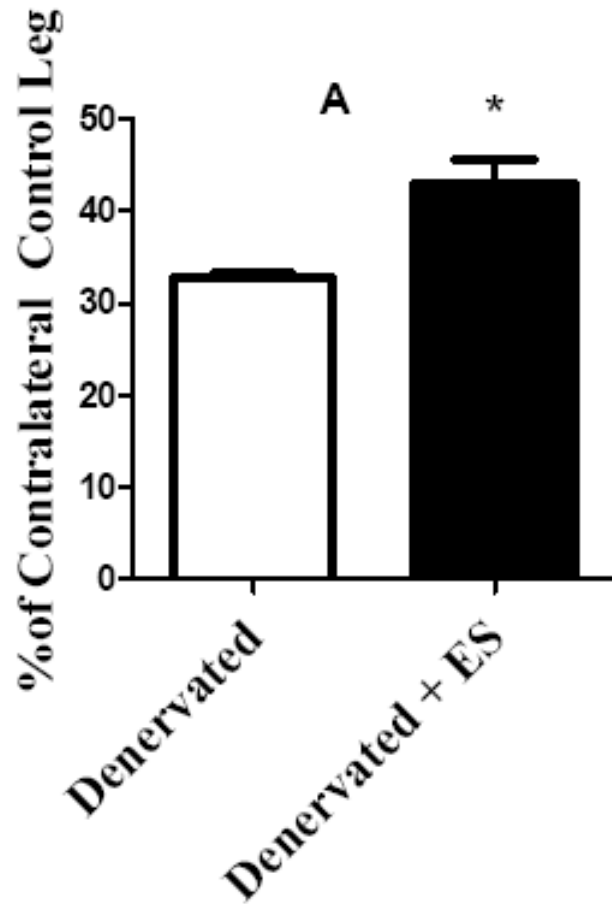
Rat in Holder



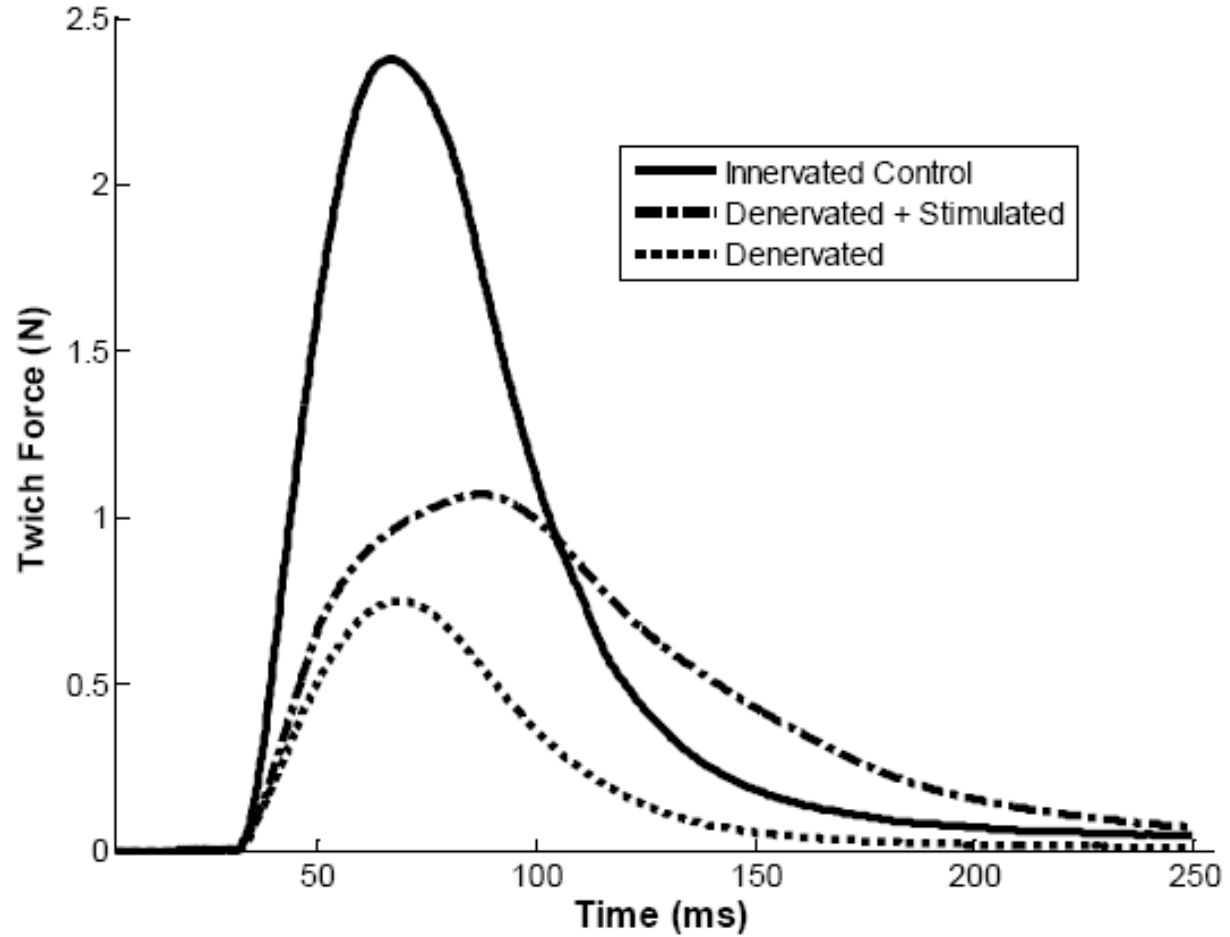
Functional Results

Weight

Twitch Force

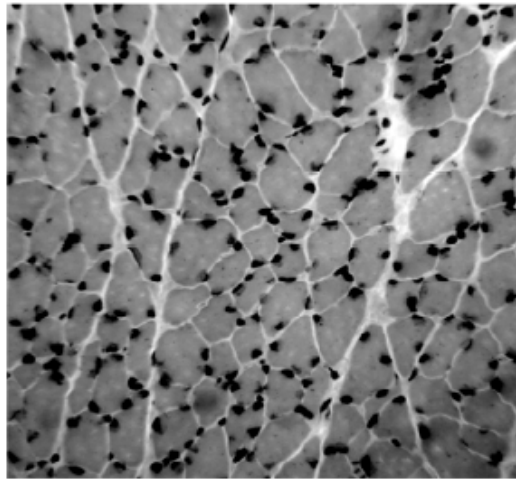


Muscle Twitches

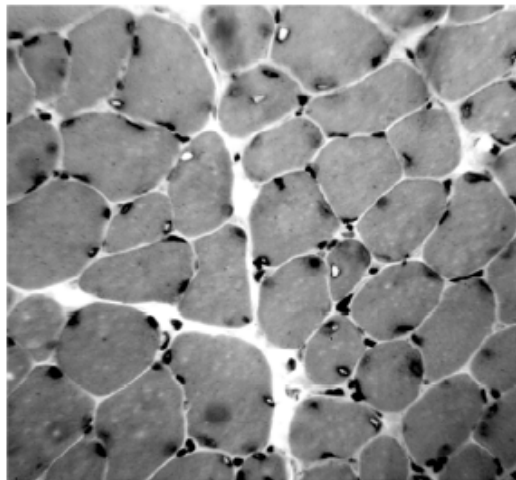


Histological Results

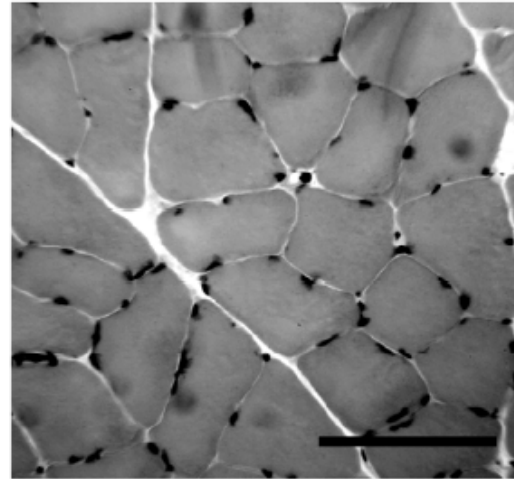
A-Denervated, B-Denervated plus Stim, C-Control



A



B



C

Does FES Improve Recovery?

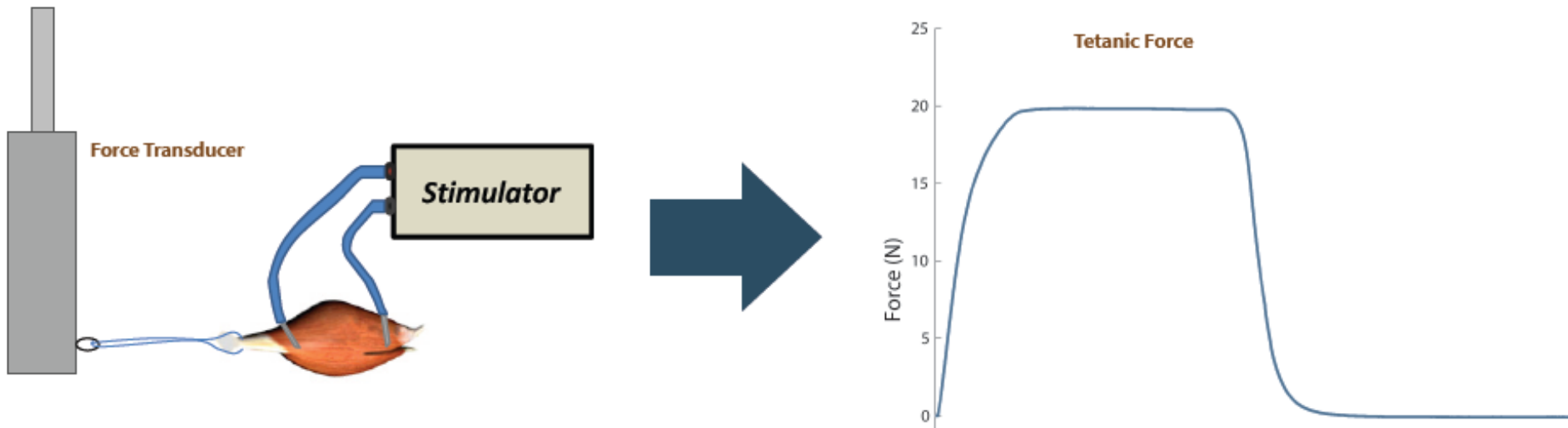
a) denervated



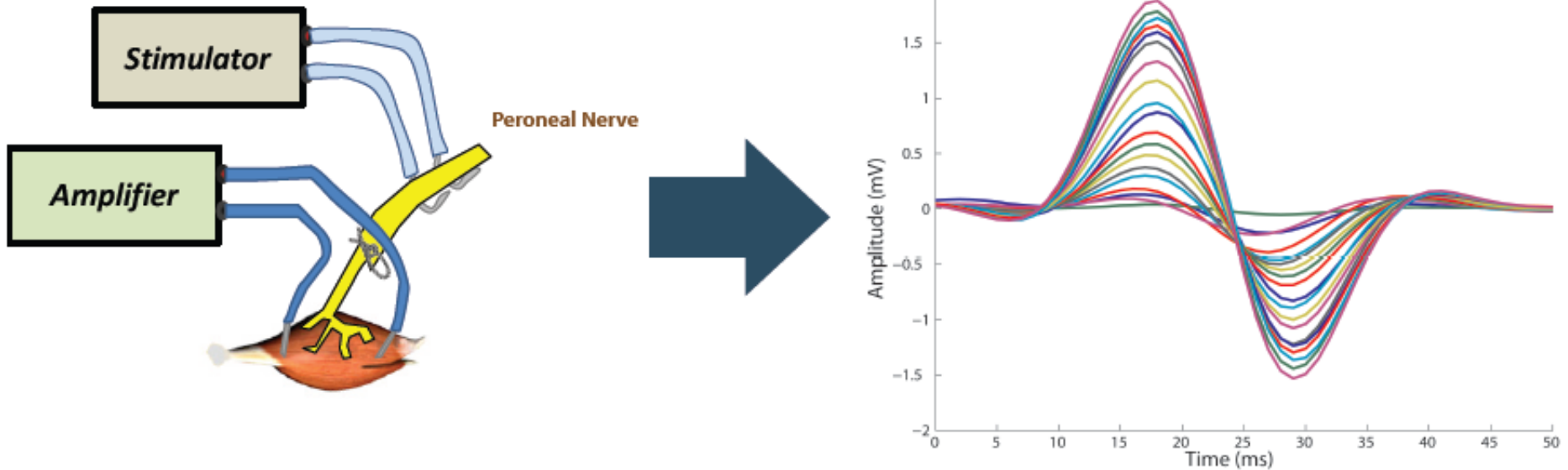
b) sensory protected



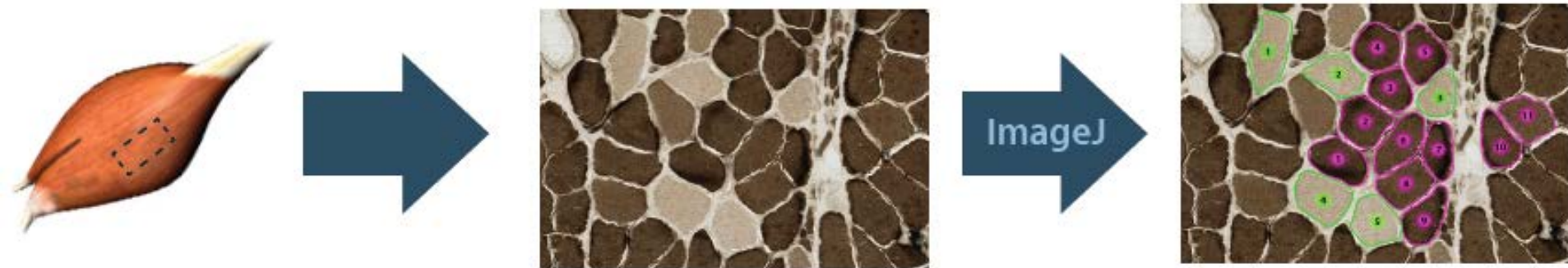
Endpoint Measures (Twitch and Tetanic Force)



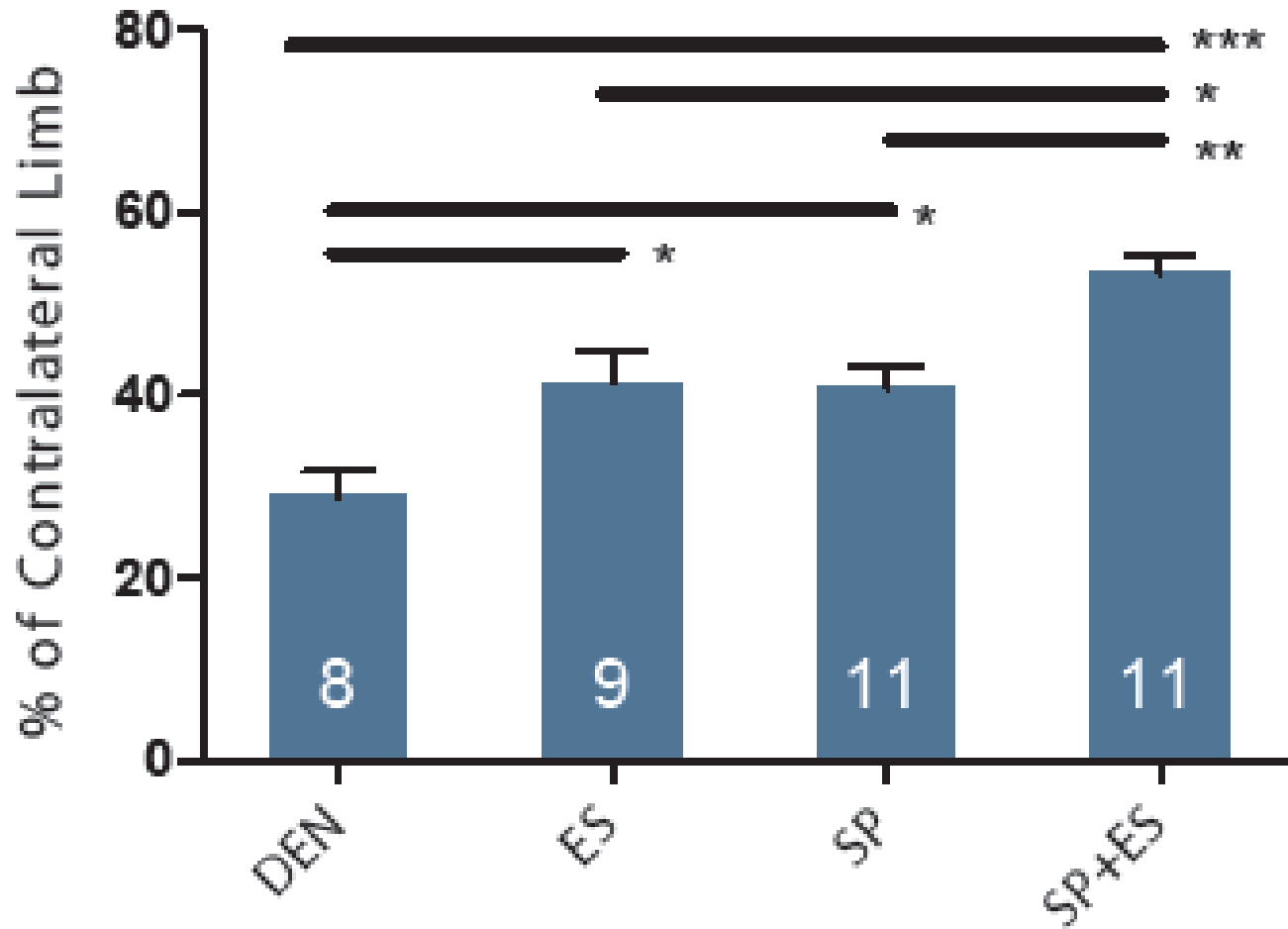
Endpoint Measures (Motor Unit Counts)



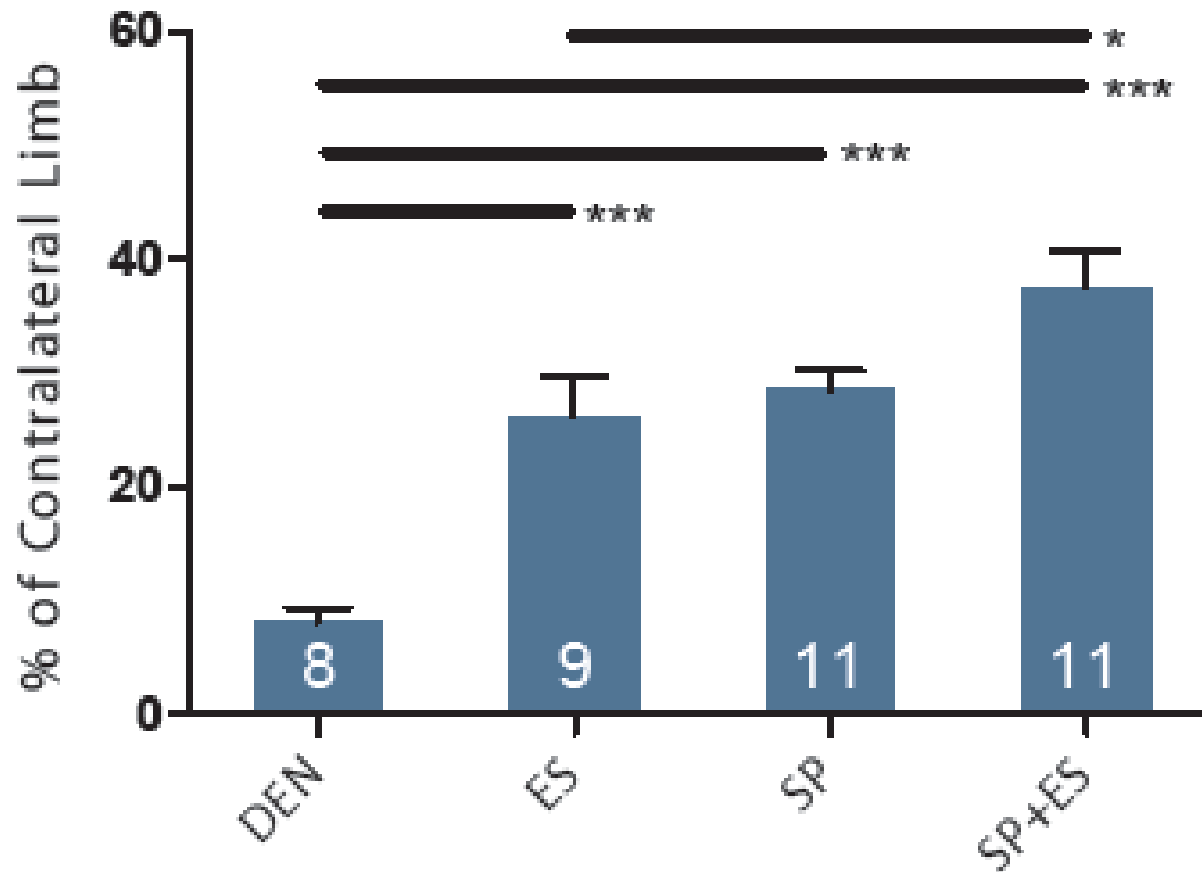
Endpoint Measures (Fiber Size and Type)



Results (Muscle Weight)

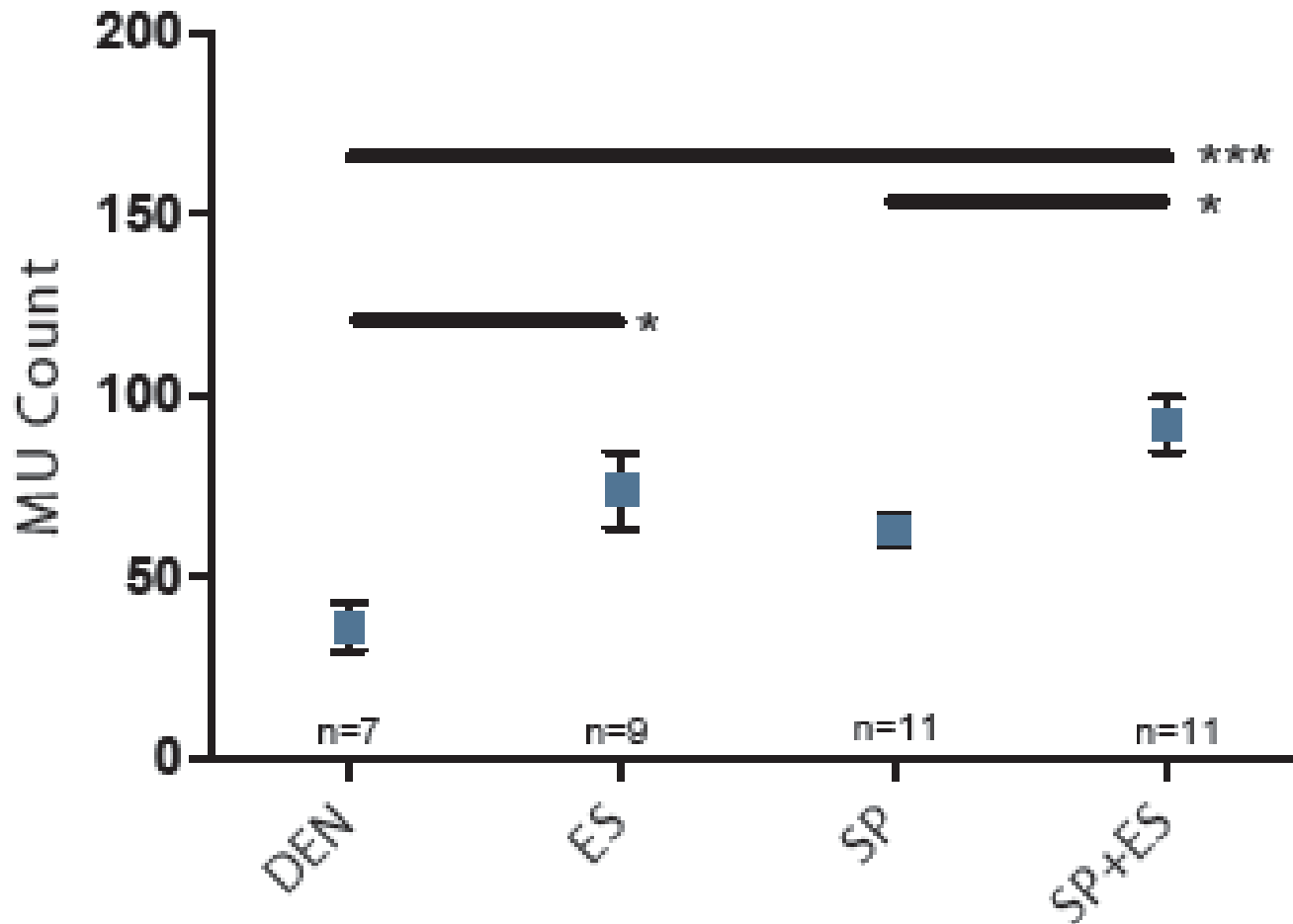


Results (Twitch Force)

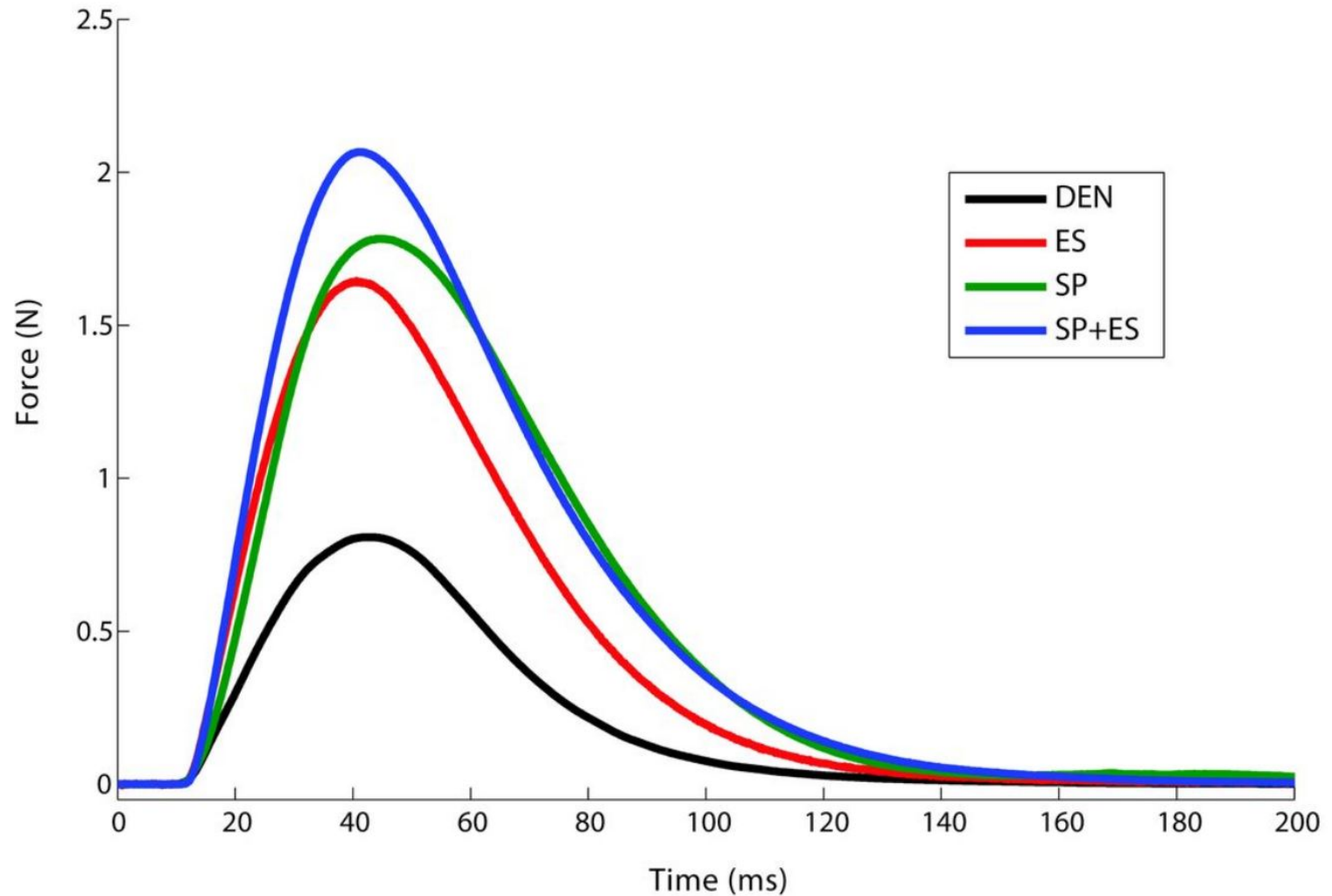


Results

(Motor Unit Numbers)



Muscle Twitches



Results (Histology)

