Utilizing an Artificial Positive Feedback Loop to Control Intramuscular Stimulation for Muscle Weakness

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PROBLEM

Foot drop symptom is known as the inability to lift the foot during walking.

Symptoms:

1. High stepping gait 2. Exaggerated swing motion

Disease commonly associated:

* ALS
* Parkinson's disease
* Multiple sclerosis
* Stroke
* Incomplete spinal cord injury

Treatment: **Functional Electrical Stimulation**

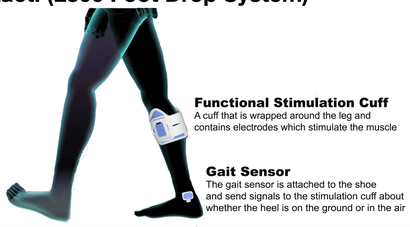
By using electrical stimulation on the peroneal nerve during footfall of the swing phase in the gait cycle, the muscle contraction could be amplified and, therefore, restore the patient's regular gait cycle.

CURRENT TECHNOLOGIES

There are two available methods for controlling the on and off of the FES(Functional Electrical Stimulation) system.

1. Tilt Sensor (Walk-aid)

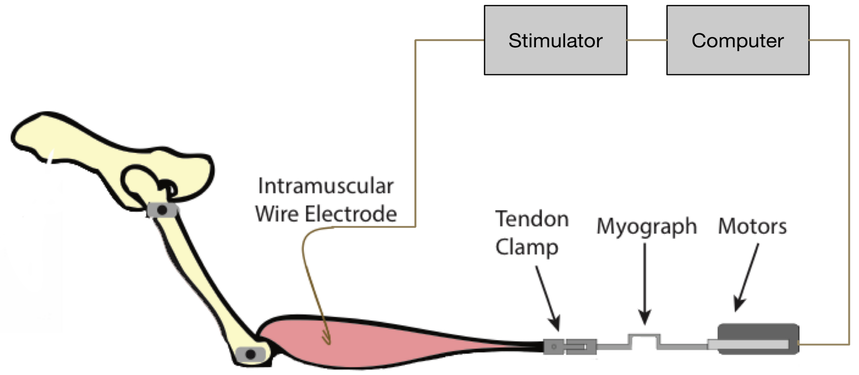
2. Foot contact. (L300 Foot Drop System)



PURPOSE

We propose to measure voluntary muscular action through force (or EMG) recordings and use that signal to further activate the muscle through stimulation. Since positive feedback can become unstable unless the loop gain is less than 1, we wanted to investigate the stable range of the stimulation parameters (threshold & gain). We used a muscle preparation with "intent" mimicked by muscle stretch & release. Stability was determined when additional force was evoked by stretch and terminated by release of muscle. An additional goal was to use this system to understand the functional role of force feedback.

METHODS

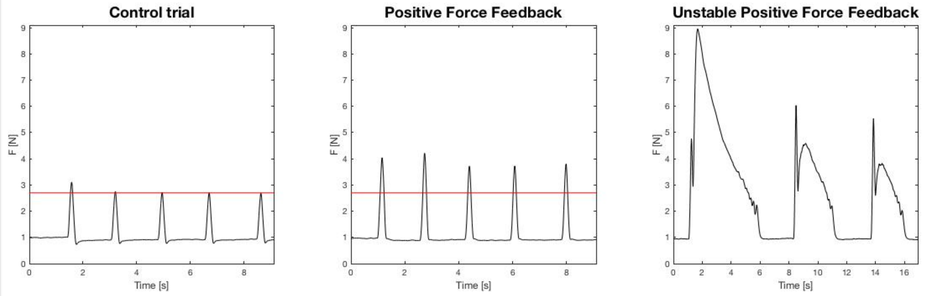


Schema of Experimental Design and the Arrangement of the Apparatus.

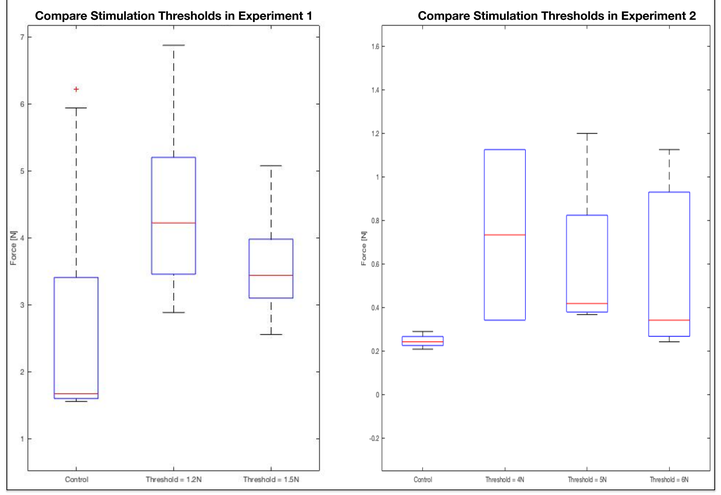
In a decerebrate cat, the gastrocnemius muscle was carefully dissected from the other muscles and instrumented with an intramuscular wire electrode. The tendon of the gastrocnemius muscle was connected to a linear motor that delivered a ramp and hold stretch 2mm in amplitude. We recorded muscular force using a strain gauge myograph which was placed between the linear motor and the muscle. The stimulator was activated when the force reached a given threshold, and the stimulus rate was varied according to a specified gain setting. We therefore varied the stimulation with the parameters of threshold and gain.

Flow Chart of the Stimulation Mechanism

TYPES OF FORCE RESPONSE



RESULTS AND DISCUSSION



CONCLUSIONS & FUTURE WORKS

We identified a stable range of parameters for which the added stimulation was controlled by stretch and release, though this range differs from experiment to experiment.

The future studies will incorporate a micro-electric array for stimulating at several sites on the muscle asynchronously to approximate physiological activation. This can ensure smooth muscle force output.

In future clinical studies, EMG sensors could be used to detect muscular activation and individually programmed for the user to use the FES with their intention instead of external triggers.

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