An Investigation into Functional Electrical Stimulation Induced Fatigue and Compensation in Healthy Young and Older Adults

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1. Introduction

Functional electrical stimulation (FES) is a commonly used rehabilitation tool that involves the application of an **electrical stimulus** to activate particular **muscle** groups to produce functional movements.

FES causes muscle fatigue, which may reduce its effectiveness as a technology to improve impaired **upper limb** movement in **stroke patients**. This study aims to identify if general controllers can be used to compensate for muscle fatigue.

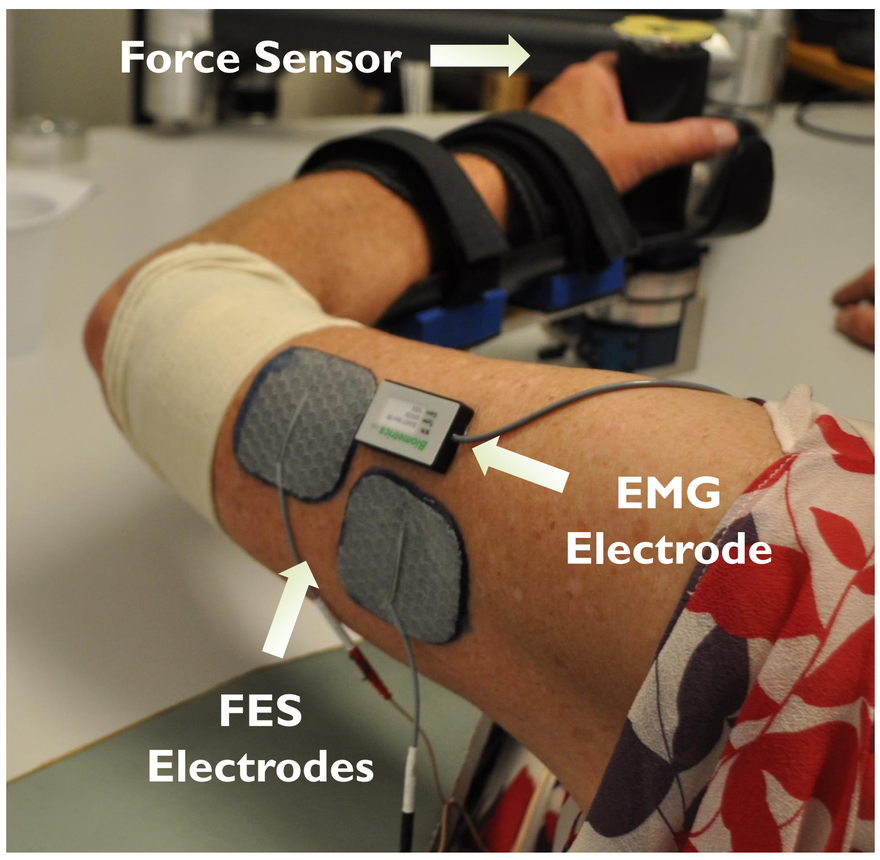
2. Experiment Setup

Gel FES electrodes over **triceps**.

Forearm positioned in support with **force sensor**.

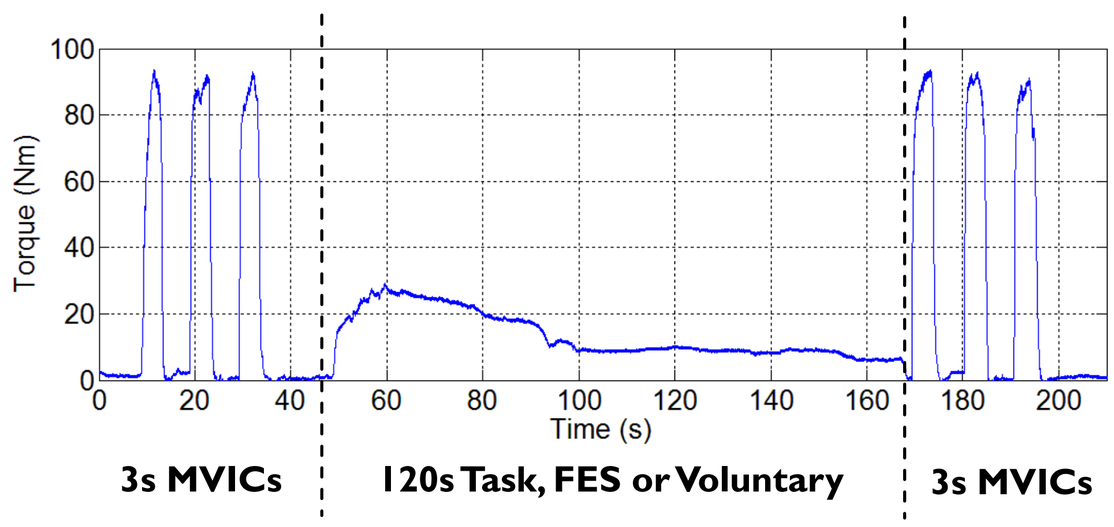
Electrical stimulation applied, resulting torque measured.

EMG electrode used to measure muscle activation before and after **contraction task**.



3. Phase 1 - Fatigue Test

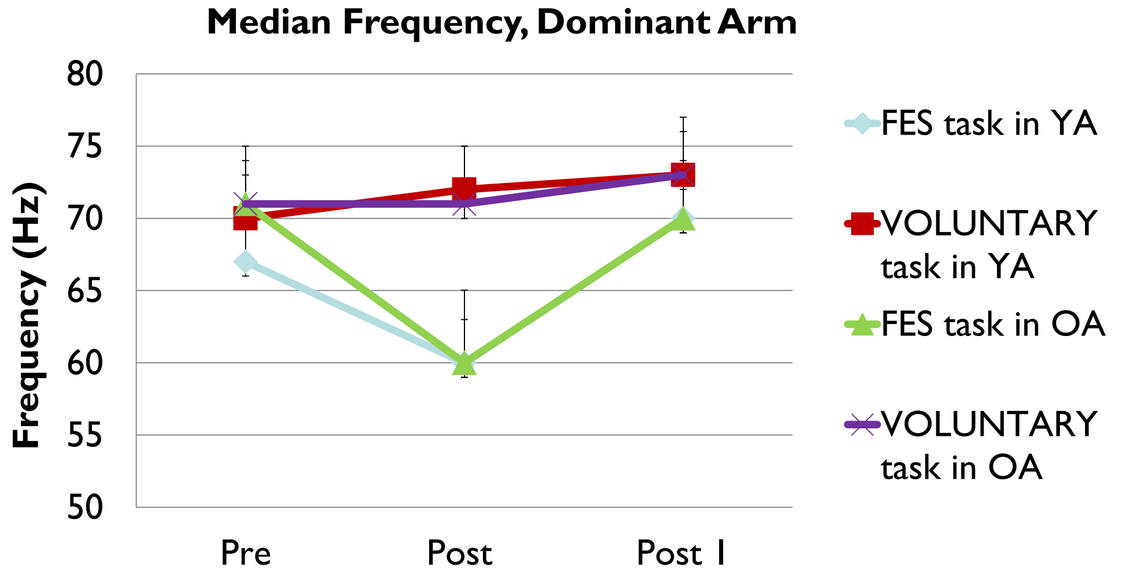
Triceps **fatigue profiles** from both arms of **healthy young (18-30 years) and older (50+ years) adults** were assessed during **isometric contractions**. Participants performed two identical contraction tasks, the first using continuous FES, and secondly using voluntary effort.



Fatigue was evaluated by taking electromyography (EMG) measurements during a series of **Maximal Voluntary Isometric Contractions** (MVICs) before and after each task.

4. Phase 1 - Results

8 Young Adults (YAs) and 6 Older Adults (OAs). **Mean** (MF) and **Median** (MDF) frequencies of the EMG data were calculated.

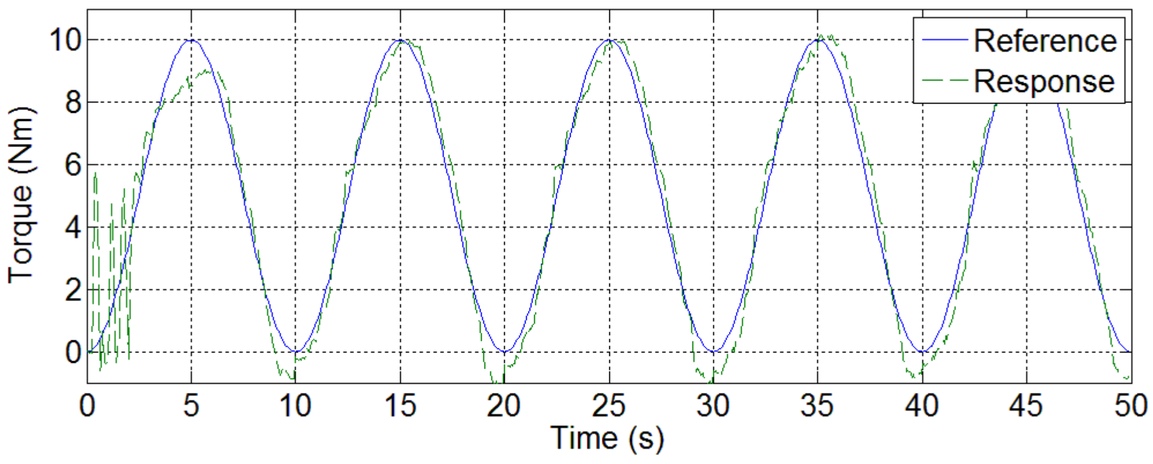


'Pre' measurement taken immediately before task, 'post' measurement taken immediately after, and 'Post 1' measurement taken 2.5 minutes later.

The results show that the use of FES results in higher levels of fatigue (there is a larger drop in median frequency) when compared with voluntary muscle activation in both older and younger adults.

5. Phase 2 - Controller Test

9 OAs were recruited. Participants supplied **zero voluntary effort** while FES was applied to the triceps. The pulse duration of FES was automatically varied (0-300μs) by two different types of controller (**fixed optimal**, and **estimation-based multiple model switched adaptive control (EMMSAC)**). Fatigue compensation was assessed by measuring the torque developed during repeated identical triceps contraction tasks.



Key Result: The adaptive controller (EMMSAC) was able to provide superior trajectory tracking (27.5% reduction in tracking error at 95% confidence) and therefore is better suited to compensating for muscle fatigue.

6. Conclusion

The results demonstrate that a general model of fatigue can be applied to the triceps muscles of healthy young and older adults. This allows the application of a general controller that requires minimal prior model identification. It will now be tested with stroke participants. If successful, the effectiveness of the approach will be tested in clinical trials.

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