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


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.

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.

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.