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Introduction

- Functional electrical stimulation (FES) is a method to control muscles in people with disabilities that impair muscle control such as spinal cord injuries.
- We would like to use FES to restore arm functionality.
- It is important to know how much stimulation is required to achieve specific forces.
- Muscles change day by day and as a result, so will forces they output.
- The relationship between stimulation and muscle force are shown by **recruitment curves**.
- If they do not vary significantly over time, controlling muscles will be much simpler than if they do vary.

Goal

- **Determine if and how recruitment curves vary over time.**

Approach

- 9 muscle groups tested
 - 6 trials for each muscle group
- Variation was tested at: stimulation value at 10% & 90% muscle force
- Tested for variation in muscle groups using box plot outliers as a metric
- Stimulation ranges were calculated at key points.

Results

- Box plot elimination method calculated 3 - 4 points as outliers for every muscle group.
- Muscle group 9 (Upper Pectoralis) had the smallest stimulation range. Muscle group 6 had the largest. Others fluctuated between.
- Stimulation range was generally smaller at 10% force than 90% force.
- Recruitment curves vary with time.

Results continued

Fig 1. Each boxplot was calculated excluding one stimulation value at 10 or 90% force. If the excluded value was outside the interquartile range (IQR), it was considered an outlier, thus variation.

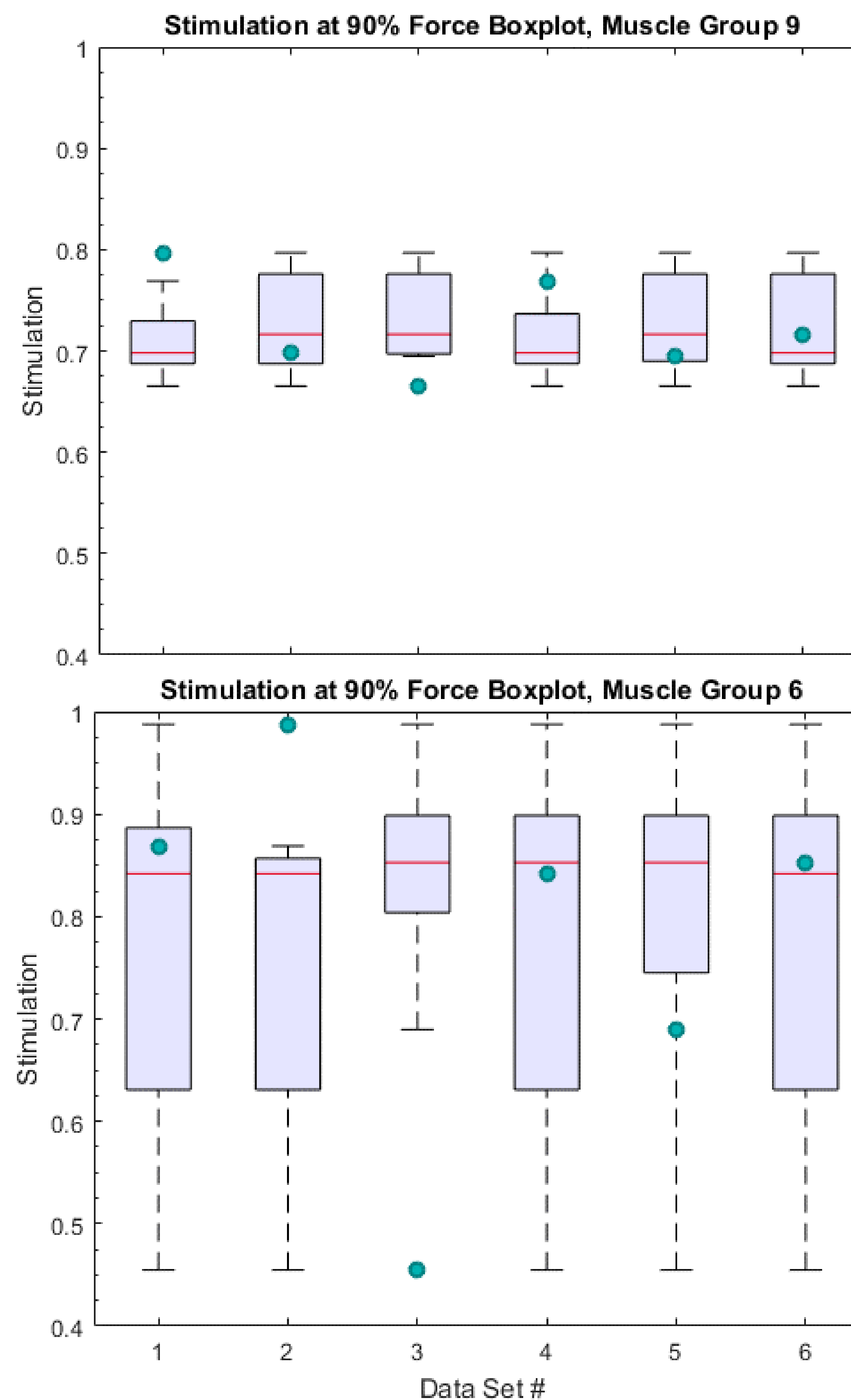
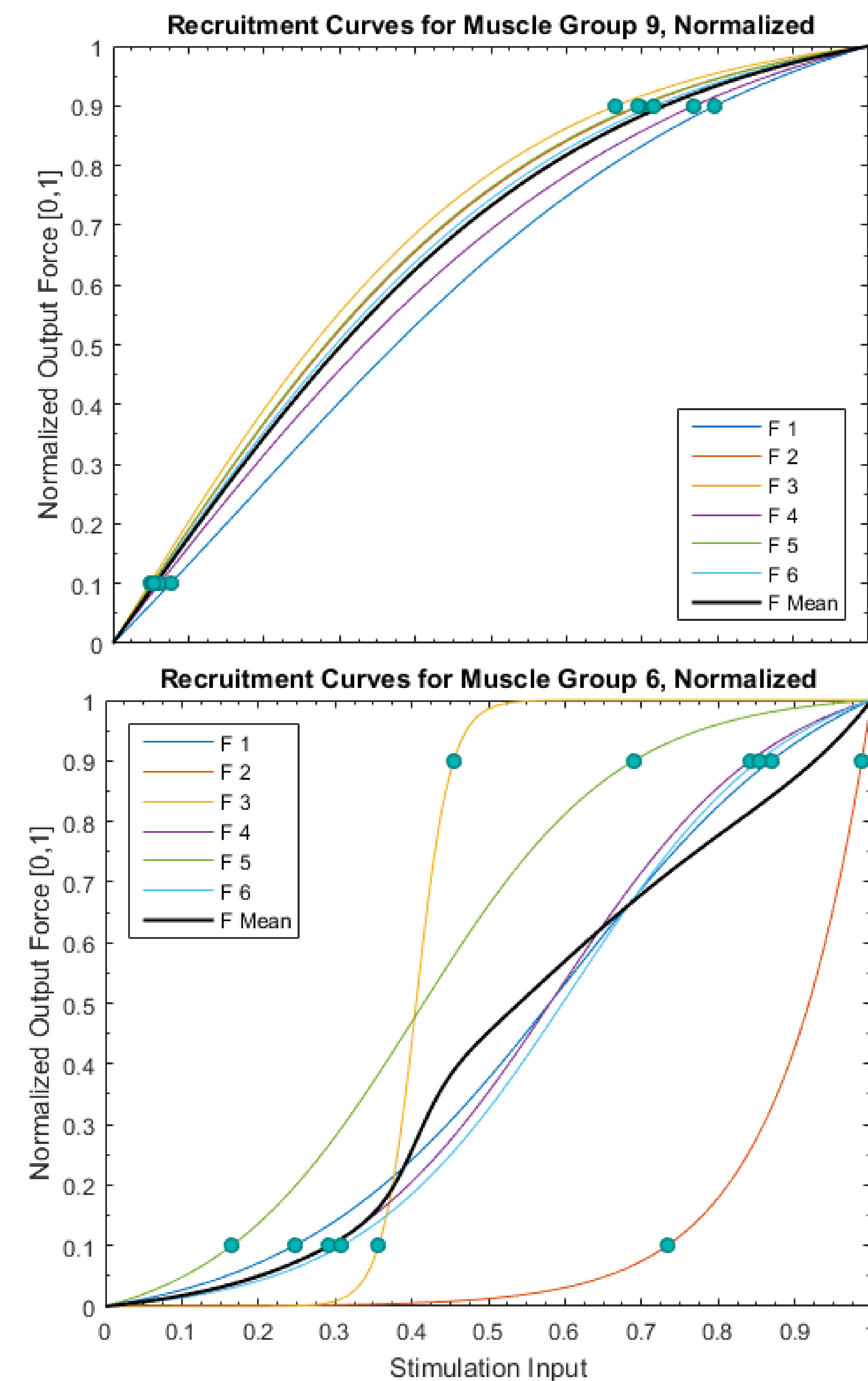


Fig 2. Recruitment Curves for muscle groups 6 and 9. Points are stimulation at 10 or 90% force. Range was calculated from these.



Conclusions & Discussion

- Number of outliers insisted variation in recruitment curves.
- Suggests that the curves vary over time.
- More data will need to be taken or a new metric may need to be explored. With such a small sample size, it is hard to determine based what repeatable data should look like. The box plot method may inherently be bias.
- Based on the size of the IQR's and the range of stimulation, variation in recruitment curves may depend on the muscle group observed. Certain muscles may be more tone than others.
- It may be more difficult to control muscles. Since recruitment curves vary what force is outputted for the same amount of stimulation, predicting how much stimulation to input will be challenging.