MOTOR UNIT DETECTION IN THE STRETCH REFLEX

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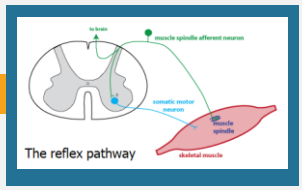
The stretch reflex: how you stay upright

The stretch reflex is responsible for **keeping muscles at a suitable length and tension**, as well as responding rapidly to environmental cues in a self-protective sense[1]

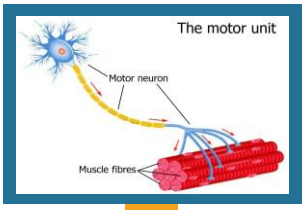


Through feedback from **stretch receptors** in skeletal muscles, the pathway works to increase or decrease muscle activity to **maintain appropriate resting muscle tone**[1,2]

Motor units: how muscles contract

The reflex works through small activation units of muscle and nerve called **motor units.** Motor units are made up of a **motor nerve** coming from the spinal cord and the **muscle fibres** that it innervates[1,2]

Tendon hammer eliciting a stretch reflex of the biceps



Understanding exactly **when and where** motor units are active during the stretch reflex could help us to **develop better treatments** for some musculoskeletal conditions, such as **cerebral palsy** or **motor neurone disease**

Methods: High-density surface electromyography (HD-sEMG)

Example set-up of high-density surface electromyography on the biceps muscle

Surface electromyography is a technique that non-invasively records the **sum of muscle activity** from the **surface of the skin**, making it a highly useful tool to study muscle function[3]. **High-density** surface electromyography uses a 2D grid of many closely spaced electrode sensors, able to capture muscle activity with far greater sensitivity[2,3]

HOWEVER

This technique is typically used to study voluntary contraction, where the overall muscle activity is far greater than that seen during the stretch reflex[3,4]

Questions1. How can we optimise the number of motor units recorded from the stretch reflex?
Questions 2. Do reflex motor units differ from those activated during voluntary movement?

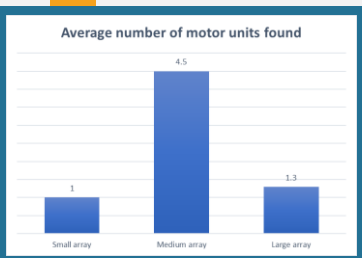
What we compared:

- Electrode array **size** and dimensions
- Electrode array **placement** on the biceps
- Signal parameters including **filters**
- Voluntary vs. reflex motor units

How we compared:

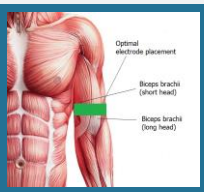
- We recorded muscle activity from the biceps muscle while evoking the stretch reflex with a tendon hammer
- Decomposition software[5] then detected individual motor units from the overall signal – like **isolating single conversations at a loud party**

Results 1. Optimising HD-sEMG for reflex



We found the highest average of 4.5 motor units using a medium electrode array with 8 mm electrode spacing, compared to an average of 1 motor unit with a small array (4 mm spacing) or 1.3 with a large array (10 mm spacing)

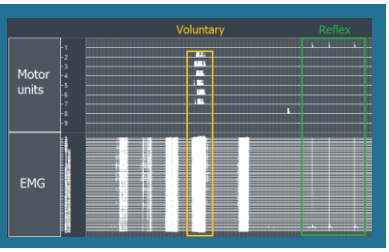
Signals were processed using a 10 Hz low pass filter and a 900 Hz high pass filter

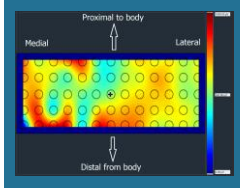


Maximal motor units were obtained with electrode placement across the bicep, 3-5 cm distal to the muscle belly centre

Results 2. Voluntary vs. reflex motor units

Different motor units are activated during voluntary movement (yellow box) and the stretch reflex (green box)





An activation map showing areas of high muscle activity (red) and low muscle activity (blue) taken during the reflex illustrates how motor unit activity differs across the muscle

Conclusions 1: 8 mm electrode spacing 3-5 cm from the muscle belly is optimal for recording stretch reflex-activated motor units
Conclusions 2: Reflex motor units differ from those activated during voluntary movement

Why our research matters and where it's going

Modular prosthetic limb from Angus McMorland's previous work

Not only could our research help to **develop treatments for some musculoskeletal disorders**, but our findings could be key in **optimising independent motor control of modular prosthetic limbs using the person's own, existing nervous system**

Our next question asks if stretch reflex-activated motor units exist in **sub-compartments in different areas of the muscle**, and if these locations of motor units are **fundamentally different** from locations activated during voluntary movement

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