

Estimates of motor unit number and size following two weeks of unilateral lower limb suspension: preliminary findings

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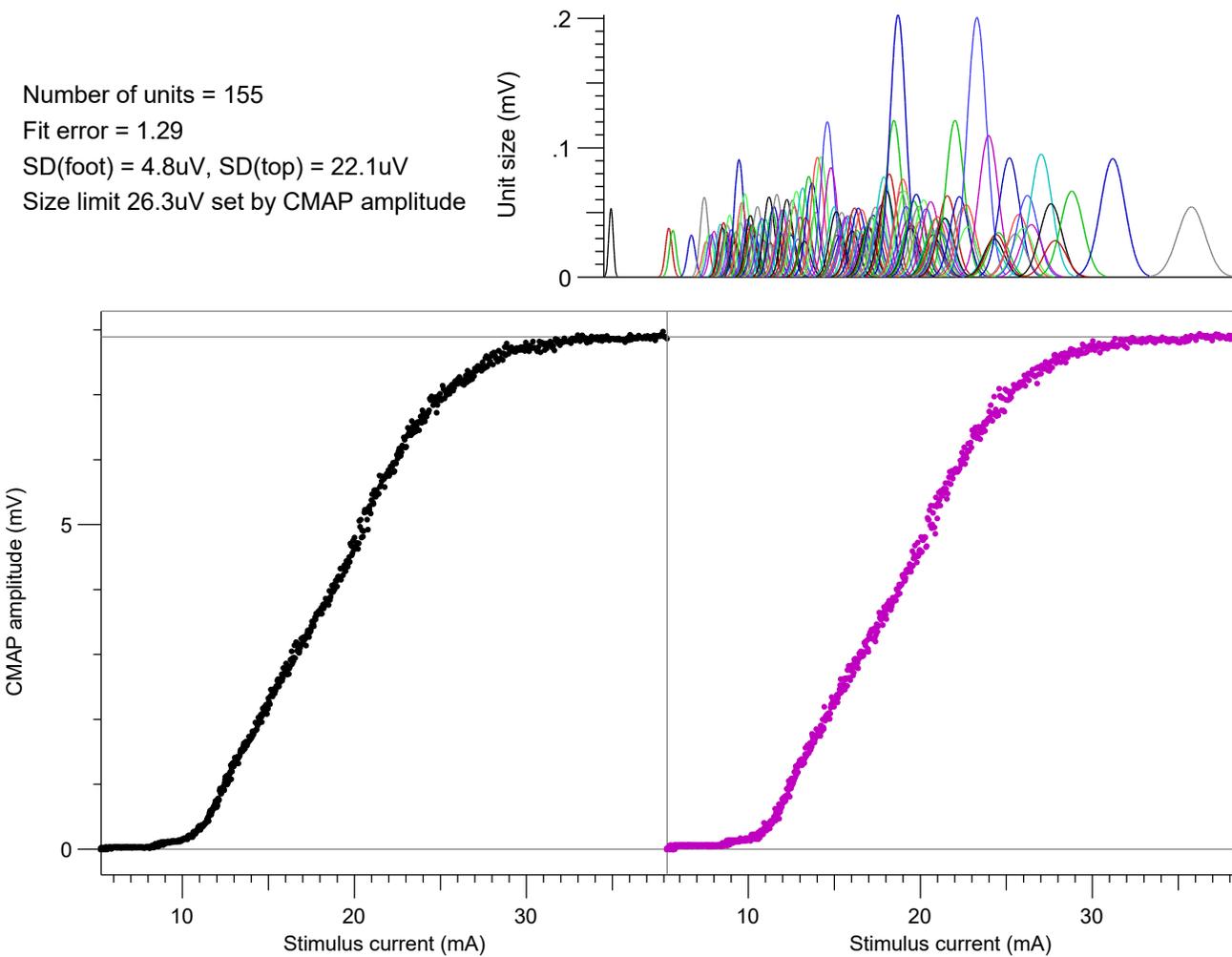
Introduction: In healthy ageing, motor unit loss typically only starts in the seventh decade of life. However, prolonged reductions in muscle activity, such as those experienced in microgravity, may trigger early muscle denervation and a preferential atrophy of fast-twitch muscle fibres. Rodents exposed to spaceflight exhibit motoneuron loss, and Earth-based unloading models in humans reveal signs of muscle denervation via EMG changes and molecular biomarkers. To the best of our knowledge, two human studies have estimated motor unit number changes post-unloading, reporting null findings that could reflect short intervention durations, examination of muscles with low unloading sensitivity, or suboptimal microgravity analogue conditions. Here, we used a motor unit number estimation (MUNE) approach to assess motor unit number and relative motor unit size in the highly unloading-sensitive soleus muscle following 14 days of unilateral lower-limb suspension (ULLS).

Methods: Preliminary data from participants who have completed the study to date are included. Seven healthy participants (two females) completed two weeks of ULLS, walking on crutches with one limb fully unloaded and the contralateral limb raised via an elevated shoe. Before and after ULLS, the tibial nerve of both legs was stimulated at rest and single-channel soleus EMG acquired. Stimulus intensity was decreased in 0.2% steps to generate compound muscle action potential (CMAP) stimulus-response curves. MUNE was conducted using the MScanFit method, which applies a statistical model to fit a simulated CMAP scan to the recorded data. The size of the largest and smallest 5% of motor units was also estimated and expressed as percentage of the maximal M-wave.

Results: An average of 1080 ± 132 traces were analysed per trial, and the mean fit error of the simulated scans was 3.7 ± 1.9 %. MUNE values were not significantly different between legs or timepoints (pre-control: 132 ± 33 ; post-control: 129 ± 26 ; pre-unloaded: 123 ± 24 ; post-unloaded: 137 ± 24). The relative size of the largest motor units decreased significantly ($p < 0.05$) from pre- to post-intervention in the unloaded leg (2.26% [1.76, 2.75] vs. 1.94% [1.45, 2.44]) but not in the control leg (2.04% [1.54, 2.54] vs. 2.30% [1.80, 2.79]). Conversely, the relative size of the smallest motor units increased significantly in the control leg (0.354% [0.345, 0.363] vs. 0.370% [0.361, 0.379]) but not in the unloaded leg (0.353% [0.344, 0.362] vs. 0.357% [0.348, 0.366]).

Conclusion: These data do not provide evidence of motor unit loss in the soleus following two weeks of ULLS. However, the observed shifts in relative motor unit size suggest early alterations in motor unit properties. Given the small sample size, these findings are preliminary, and larger cohorts are needed to confirm whether electrophysiological MUNE approaches can be sufficiently sensitive to detect changes in motor unit size distribution after unloading.

Number of units = 155
Fit error = 1.29
SD(foot) = 4.8uV, SD(top) = 22.1uV
Size limit 26.3uV set by CMAP amplitude



Example of motor unit number estimation (MUNE) using MScanFit. Stimulus intensity was gradually reduced in 0.2% steps to generate a compound muscle action potential (CMAP) stimulus–response scan. The measured CMAP scan (black) is shown alongside a simulated scan produced by MScanFit (pink). MScanFit fits the model in three steps: (1) assessment of baseline CMAP variability before and after the scan, (2) generation of a preliminary model based on how the slope and variability of the scan change with stimulus intensity, and (3) model optimisation until the simulated scan closely matches the recorded data.

