Motor Unit Magnetic Resonance Imaging (MU-MRI) to Determine the Morphology and Distribution of Human Motor Units.

Number of words (342 of 350)

Authors: Matthew G. Birkbeck [(1) (2) (3)], Ian S. Schofield [(4)], Linda Heskamp [(1)], Roger G. Whittaker [(5)], Andrew M. Blamire [(1)]

Background: Linear dimensions of the human motor unit (MU) have been investigated using invasive needle electromyography whilst glycogen depletion experiments in animals infer shape and size of MUs. MRI can detect signal changes consistent with motor unit activity and provides a non-invasive method to study the human MU in more detail than conventional techniques.

Aims: To use MUMRI to study size, shape, distribution and recruitment order of human MUs in healthy volunteers using a protocol of ramped electrical stimulation.

Methods: Leg muscles of 6 healthy volunteers **(**mean age: 44 years, range: 29-80 years), were scanned using a 3T Philips MR scanner and a pair of 10cm elliptical surface coils during incremental electrical stimulation of the left peroneal or tibial nerve. To define the first MUs which were activated, DWI images were acquired time-locked to the electrical stimulation with sensitization along the muscle fibre axis (Single Shot SE-EPI, b = 20 s/mm^2, voxel size=1.5x1.5x7.5 mm, TR/TE = 1000/36 ms, Δ/δ = 18.5/4.5 ms). The electrical stimulation started at a current showing clear signal change and was decreased in steps of 0.01 mA until signal changes were not present (5 repetitions per stimulus strength, 1080 stimuli).

MU activity maps were created by taking the difference between the images with signal change and those without. These images were used to determine the Feret diameter of resultant signal hyper-intensities, which reflect the MU activity. Images were also used to record recruitment order and morphology.

Results: During graded reduction in electrical stimulation strength the signal voids representing MU activity appeared sequentially in defined regions comprising multiple pixels. As the MU approached the firing threshold we observed alternation of signal changes in consecutive images until no activity was observed. Detected MUs were ovate shaped. Minimum and maximum Feret diameters of the first active MU were 6.4 mm (range: 4.3-11.7) and 12.7 mm (range: 8-18.8 mm) respectively.

Conclusion: MUMRI was able to detect the first activated MUs using an incremental electrical stimulation protocol. Observed alternation is a further support of the signal changes being indeed MUs. The detected MUs had Feret diameters in agreement with literature.