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MUSCLE DAMAGE AFTER NEUROMUSCULAR ELECTROSTIMULATION ASSESSED BY MULTIMODAL MAGNETIC RESONANCE IMAGING



SIEMENS

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Introduction

Neuromuscular electrostimulation (NMES) is useful for improving muscle function. However, it has been reported that NMES-induced muscle damage is mainly due to the specificity of motor unit recruitment (i.e., non-selective, spatially fixed, synchronous and mainly superficial). Moreover, it is documented that NMES results in a preferential activation of muscle fibers beneath and close to the stimulating electrodes (1), so that one could expect heterogeneous damage between directly and indirectly stimulated muscles.

The present study aimed to test the hypothesis that NMES-induced muscle damage would be different between directly and indirectly stimulated muscles of the knee extensors using multimodal magnetic resonance imaging (MRI) including T₂ mapping and diffusion tensor imaging (DTI).

Methods

Twenty-five young male subjects took part in a single bout of NMES with the electrodes being placed over the belly of vastus lateralis (VL) and vastus medialis (VM, Figure 1).

NMES session consisted in 40 isometric contractions (5s on and 15s off) evoked with pulses delivered at 75Hz (pulse duration of 400µs). Intensity was increased until maximally tolerable level.

Results

Mean increases in T_2 (Figure 2-A) were larger for the VL (+19.5%) and VM (+6.7%) when compared with the VI (+4.3%) and RF (+2.9%).

Significant increases in λ_3 for VL, VM and VI (+7.3%, +3.7%) and +2.3% respectively, Figure 2-B) and a decrease in FA only for VL (-7.0%, Figure 2-C) were observed (P < 0.05).

Figure 1: Subject position during the NMES session (Top) with electrodes (in black and yellow) placed on vastus lateralis and medialis (Bottom). Axial slices were obtained for proximal and distal part of thigh muscles corresponding to





the electrodes' placement.

MRI parameters were assessed before and 4 days after the NMES session using a 1.5T scanner (Siemens[®]) Avanto, Erlangen).

 T_2 mapping: TR = 4800ms; TE = 15/25/35/45/55ms; 20 slices; thickness = 6 mm.

DTI : TR = 5000ms; TE = 53ms; 12 directions; b-values = 0 and 500s/mm².

Mean T₂ values, radial diffusion (λ_3) and fractional anisotropy (FA) were determined in VL, VM, vastus intermedius (VI) and rectus femoris (RF) muscles.



MRI parameters were largely and heterogeneously affected as a result of a single NMES session, thereby clearly illustrating major muscle alterations. The extent of muscle damage was greater for muscles beneath stimulation electrodes which is consistent with the spatial distribution of blood flow in directly stimulated muscles (3).

Interestingly, the largest alterations were found in the deeper part of VL. This unexpected result might be related to the activation of deep intramuscular nerve branches and/or shear stress between muscles leading to inflammation of connective tissues (4).

Finally, the extent of changes varied between T_2 and DTI metrics, indicating that the corresponding indices likely reflect different physiological processes and highlighting the relevance of multimodal MRI for monitoring in vivo skeletal muscle injury.

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