CHANGES IN MUSCLE $T_2$ RELAXATION PROPERTIES FOLLOWING SPINAL CORD INJURY AND REHABILITATION

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Introduction

Magnetic resonance (MR) is a noninvasive method, which can be implemented to study structural and biochemical properties of skeletal muscle. Changes in proton transverse relaxation ($T_2$) properties have been used to study muscle cellular damage in healthy and diseased muscle, as well as muscle activation during a variety of exercise protocols. The objective of this study was to implement MR imaging to characterize the $T_2$ relaxation properties of the rat hindlimb muscles following spinal cord injury (SCI) and locomotor training.

Experimental

Spinal cord contusion injuries were produced using a NYU (New York University) impactor device. Twenty-four Sprague Dawley rats were assigned to either treadmill training, cycle training or an untrained group. Both training protocols were started at 1-week post injury and were performed continuously for 3 months, 5 days/week, 2 trials/day, 20 minutes/trial. Images of the lower hindlimbs were acquired using a spin-echo sequence with a pulse repetition time of 2 sec, 256x128 matrix, 2.5 x 2.5 cm$^2$ field of view, 1-mm slice thickness, and echo times of 14 ms and 40 ms. $T_2$ measurements were performed in the tibialis anterior, soleus, and gastrocnemius muscles. The muscle boundaries were outlined, and the mean muscle $T_2$ values and a $T_2$ map were calculated according to a previously described method, assuming a single exponential decay with respect to TE. The mean muscle $T_2$ value was determined in at least 8 image slices for each muscle (1mm thickness).

Results and Discussion

Following midthoracic spinal cord contusion injury, we observed a significant shift in the $T_2$ relaxation properties of the rat hindlimb muscles. The largest increase in $T_2$ was noted in the soleus muscle (+17.9%), which resulted in significant $T_2$ contrast in the hindlimb muscles as early as 1 week post-SCI. Both training paradigms, treadmill and cycling training, accelerated the recovery in the $T_2$ relaxation properties following SCI resulting in normal soleus $T_2$ values in the training groups at 4 weeks post-SCI, versus 12 weeks post-SCI in the non-trained animals. Finally, in vitro histological assessments of rat skeletal muscles demonstrated that there was no apparent muscle injury in any of the muscles (Figure).

Conclusions

This study demonstrates that rats following SCI show a significant shift in the $T_2$ relaxation properties of the rat hindlimb muscles and early intervention strategies can effectively accelerate muscle $T_2$ recovery.

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