Rapid Volumetric T2 Measurements in Muscle Pre- and Post-Exercise using Quantitative DESS
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Introduction: The evaluation of muscle for medical and research applications is enhanced by MR techniques that acquire morphological and biochemical tissue properties from the entire muscle volume. T2 relaxation time in muscle increases after activity. Unfortunately, conventional spin echo (SE) techniques used to acquire two-dimensional (2D) T2 maps suffer from long acquisition times, blurring, artifacts, and incomplete coverage. A quantitative three-dimensional double echo steady state (qDESS) sequence, capable of acquiring accurate 3D qDESS quantification of T2 relaxation times, was recently validated in vivo in the articular cartilage [1]. Several studies have investigated the effects of exercise on T2 changes in muscle, most recently demonstrating an increase in T2 value after exercise at 35T-1.5T in several muscles. None have yet done so with 3D methods in a 3.0T system [2-5]. We evaluated the effect of exercise upon the diffusion properties of muscle using a 3D qDESS sequence at 3.0T in vivo.

Methods: All images were acquired in the coronal plane in a GE MR 750 3.0T MRI scanner (GE Healthcare, Milwaukie, WI) with a torso array coil. Bilateral images of volunteers’ calves were imaged with 3D qDESS sequences. Imaging parameters were: spoiler gradient duration: 2ms, matrix: 256x256, receiver bandwidth: ±62.5kHz, FOV: 36x36cm2, slice thickness: 4mm, TR: 29ms, and TE for the S+ readout: 10ms and S-readout: 40ms. The images were then processed and segmented (GCMs and mGCMs) and used to calculate the mean and SD of the estimated T2 values for each subject. All images were processed and segmented (GCMs and mGCMs) and used to calculate the mean and SD of the estimated T2 values for each subject. All images were processed and segmented (GCMs and mGCMs) and used to calculate the mean and SD of the estimated T2 values for each subject. All images were processed and segmented (GCMs and mGCMs) and used to calculate the mean and SD of the estimated T2 values for each subject. All images were processed and segmented (GCMs and mGCMs) and used to calculate the mean and SD of the estimated T2 values for each subject. All images were processed and segmented (GCMs and mGCMs) and used to calculate the mean and SD of the estimated T2 values for each subject.

Results: The 3D qDESS T2 values estimated in vivo in muscle are within the ranges of previously reported T2 values and average percent changes of T2 values from baseline of all exercised muscles peaked immediately after exercise and subsequently decreased back to the baseline T2 value (Figure 1). As a measure of repeatability of the method, T2 relaxation times of each unexercised muscle were averaged to yield the average T2 values of all unexercised muscles. The average T2 values for each muscle were then compared to the averaged T2 values for each muscle (Figure 2) and in representative subjects (Figures 3-4). Although increases were seen in the difference between T2 values in all muscles immediately post-exercise, differences were only significant in the medial gastrocnemius immediately post-exercise (p<0.05).

Conclusion: High-resolution, 3D morphological images of the entire muscle and accurate T2 maps can be produced using qDESS acquisitions in <1min without distortion or blurring. The rapid acquisition times and volumetric coverage allow for examination of the entire muscle at multiple time points. Exercise induced T2 changes in skeletal muscle, which are most likely indicative of increased water mobility, are most evident immediately after exercise. Mapping of the entire muscle activation volume after exercise may be helpful in exercise studies and creation of computational models of muscle motion during human activity.


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