The Effect of Stretching Exercise Amplifying Extromyocellular Lipid Signal Intensity in Proton MRS and Its Role in Exercised-Muscle T2w MRI Image

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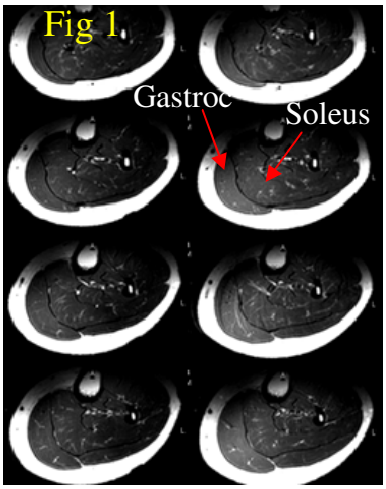
Introduction

Since the first MRI observation that the exercised muscles become "brighter" on T2w images two decades ago (1), there have been numerous interests on the study of the phenomenon as well as on its application for identifying muscles involved in particular exercise (2-6). However, the underlying physiological mechanisms are still poorly understood. It is believed that the exercise-induced muscle intensity enhancement on T2w images is a natural result of prolongation of the transverse relaxation time T2 (1-3,7,8), speculatively due to changes in water state and/or compartment volume such as an increased intracellular free to macromolecular-bound water ratio, an increased extra- *versus* intra-cellular water population ratio, and an increased extra-cellular and/or vascular fluid volumes (3). Other possible explanations include BOLD effect (2), intracellular volume increase and acidification (9). Our recent skeletal muscle MRS studies on pre- and post-exercise metabolite changes, however, provide interesting but not completely surprising evidence that, at least partly, muscle fat may contribute to the enhancement.

Method

Four healthy non-athletic adult subjects aged 26-38 years participated in the study following the guidelines of the local IRB with informed written consent. the volunteers were asked to do stretching exercises, either in-magnet by doing dorsiflex around ankle, once per 2 sec, for 3 min, or doing double-legged toe-raise out-magnet, once per 2 sec, for 3 min. Pre- and immediately post-exercise T2w images of calf muscles and localized ^{1}H MR spectra were scanned, using Philips 7T MRI scanner (Achieva, Best, The Netherlands), with leg positioned parallel in Bo field and calf muscle placed on a customized 2-channel T/R coil. Multi-slice T2w images (TR/TE=1500/70ms, TSE factor 10, thickness 5mm) and a series of ^{1}H MR spectra were were collected post-exercise for a time period of 30 to 50 minute with TR = 2 s and TE = 20 and/or 140 ms from soleus muscle (voxel size 4 – 8 ml).

Pre-Exercise Post-Exercise



Results and Discussion

Fig. 1 shows typical T2w images (4 consecutive slices) collected from left leg pre- and post-exercise collected at 7T, which apparently confirms the well-known MRI phenomenon of exercise-induced T2w image brightness, here in both soleus and gastrocnemius regions, for all participants. An average intensity increase of 28% and 41% were measured for soleus and gastrocnemius muscles, respectively. However, the ^{1}H MRS data do not always supports the mechanism of exercise-induced water T2 elongation. As shown in Fig 2, the magnitude of water signal in fact was decreased, with a broadened linewidth. This might be arguably due to worsen shimming condition. However, in the same voxel, the extramyocellular lipid (EMCL) signal became narrower. The difference spectra, obtained by subtracting post- from pre-exercise spectra, as shown in Fig 2 insert, indicate that the EMCL content is elevated, about 20% in average. This exercise-induced fat EMCL signal enhancement was observed in all subjects. It can be reasonably explained by the increased alignment of fat streaks and other connective tissues along the Bo direction after muscle stretching. Such a mechanism may be responsible, at least partly, to the phenomenon of exercise-induced muscle T2w image intensity increase.

Conclusion

This work presented MRI and ^{1}H MRS data which indicate that the exercise-induced EMCL signal intensity amplification may be responsible, at least partly, for the well-known effect of exercise-induced muscle intensity increase on T2w images. This new mechanism could be further exploited for potential medical application such as assessment of myopathies, sport training regimens and physical therapies.

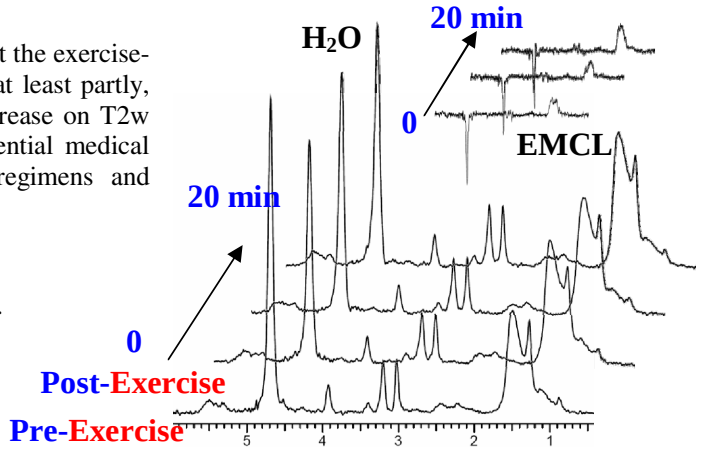


Fig 2

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