Characterisation of muscle type lipid relaxation parameters for quantification of intramyocellular lipids evolution in Zucker rats

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Introduction:

1H-MRS is being increasingly used for investigations of human and animal muscle physiology. It is clearly advantageous in differentiation between intramyocellular lipids IMCL and extramyocellular EMCL [1]. The knowledge of apparent relaxation times of IMCL and EMCL in muscle tissue is required first for optimization of sequence parameters and second for quantification. Up to now, all reported IMCL quantifications in rats were performed using creatine as reference [2]. However, in some applications creatine concentration could be changed.
In this work, we measure the relaxation time of myocellular lipids in two different muscles of Zucker rats at 7 Teslas. IMCL composition was quantified in tibialis anterior and soelus at different ages using water as internal reference assuming a constant water concentration in muscle.

Methods

MR experiments were performed on a 7T system (Bruker Biospec, Germany). A volumic birdcage coil was used for RF emission and a surface coil was used for MR signal reception.
T_2 relaxation times of water and lipids were measured without and with water signal suppression using six different echo times (18-105 ms) and TR of 2s.
T_1 relaxation times of lipids were measured with inversion recovery technique, using six different inversion times (85-2500ms) and repetition times of 3s. T_1 relaxation times of muscle water was measured using eight different inversion times (5-5000ms) and repetition time of 10s.
For the longitudinal study, spectra were acquired from a voxel size of 8 µl located in tibialis anterior (TA) and soleus (S) muscle of Zucker rats (PRESS sequence, TR/TE=2000/18ms, 256 averages, VAPOR water suppression).
All first and second order shim terms were adjusted using the FASTMAP method, resulting in a water line width of ~16 Hz.
Data were processed in the time domain using the j-MRUI software. Quantification of components was performed using AMARES. The IMCL level was expressed relatively to water signal intensity after T1 and T2 corrections.

Results:

Figure 1 shows a typical proton spectrum acquired from a soleus voxel of 8 µl with only 256 averages. Different resonances of TCr (3.05 ppm), methylene EMCL (1.5 ppm), methylene IMCL (1.3 ppm), and IMCL (0.9 ppm) are clearly identified with a good sensitivity of the NMR signal.
Means and standard deviation of apparent relaxation times measured in tibialis anterior and soleus are presented in Table1. Age and muscle-type modulated intramyocellular lipid are summarized in figure 2.

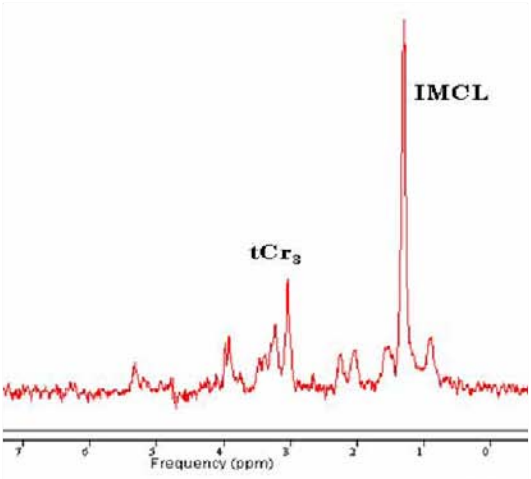

Figure1: Spectrum of soleus muscle acquired with PRESS (TR/TE=2000/18ms, 256 averages, voxel of 8 µl)

	muscles	T_1 (ms)	T_2 (ms)
Water	TA	1020±110	23.7±2
	Sol		23.4±1
IMCL(1.3 ppm)	TA	428±18	65.6±6
	Sol		63.7±4
EMCL(1.5 ppm)	TA	426±31	58.4±7
	Sol		53.8±6

Table 1: Relaxation times of IMCL, EMCL and water in muscles of zucker rats at 7T.

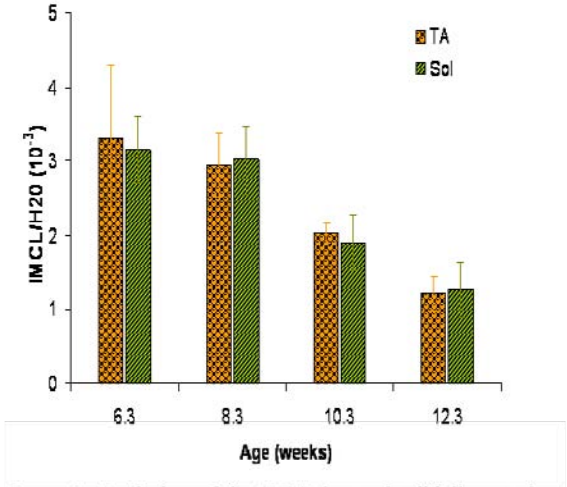

Figure 3: Evolution of the IMCL/water in tibialis anterior an soleus in zucker rats (n=4)

Conclusion:

In present study, the relaxation parameters of the two pools of lipids in zucker rats at 7 teslas are determined. Quantification of lipids independently to creatine is proposed. In this animal model, we found that IMCL levels are similar in soleus and tibialis anterior. However, IMCL level decreased between 6 and 12 weeks.

References:

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[2] C. Neumann-Haefelin, et al. [2003] MRM 50: 242-248