# Implementation and validation of localized constant-time PRESS sequence for investigation of skeletal muscle metabolism

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**Introduction:** Ongoing effort is directed to develop methods for improving spectral resolution and quantification of intramuscular metabolites at clinical field strengths. Recently, constant-time approach has been applied in conjunction with localized MRS techniques towards this goal (1-3). Earlier implementation of LCT-COSY technique (3) permits resolution of the various resonances but induces coherence transfer between the *J* coupled metabolites. In order to suppress this undesired coherence transfer, leading to cross peaks between *J* coupled spins, and thereby SNR and improve resolution of the overlapping resonances of intramyocellular (IMCL) and extramyocellular (EMCL) lipids within the soleus muscle, we have implemented and validated a localized constant-time (CT) spectroscopic method based on PRESS.

**Methods:** Localized constant-time PRESS (LCT-PRESS) was implemented on a 3T MRI/MRS scanner with a transmit / receive extremity coil. The sequence utilizes three slice-selective RF pulses [90° – ($T_{CT}$ + $t_1$)/2 – 180°- ($T_{CT}$ -$t_1$)/2 – 180° – acquisition] to achieve volume localization. The interval between the first 90° pulse and the following 180° pulse was incremented by $t_1$/2, while the interval between the 180° pulse and the final 90° pulse was correspondingly decremented by $t_1$/2. The evolution interval, ($T_{CT}$ + $t_1$)/2, was placed after the first slice selection pulse while the second evolution interval, ($T_{CT}$ - $t_1$)/2, was placed after the crusher gradients surrounding the 180° pulse. The position of the 180° refocusing pulse was, in effect, stepped through the fixed delay of $T_{CT}$. By design, the sequence exhibits spin-spin decoupling along the F1 dimension along with improved spectral separation for all overlapping resonances of IMCL and EMCL. The method was validated by simulations as well as phantom experiments, and was further applied to six healthy subjects using a 27ml voxel centered in the soleus muscle. The experiments were performed with TR/$T_{CT}$ of 2s/52ms, 40 $t_1$ increments, and 16 averages for each experiment, resulting in a total acquisition time of ~ 21 minutes.

**Results:** The overlapping resonances seen in PRESS spectrum (Figure 1) is clearly resolved in LCT-PRESS spectrum (Figure 2) recorded from a soleus muscle of a healthy subject. Note the clear separation of and the olefinic protons arising from IMCL (5.3 ppm) from those arising from EMCL (5.5 ppm) in the LCT-PRESS spectrum (Figure 2) and [$CH_2$]n groups of IMCL and EMCL resonances in the expanded plot (Figure 3).

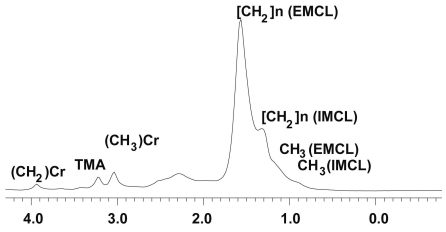


Fig 1. PRESS spectrum

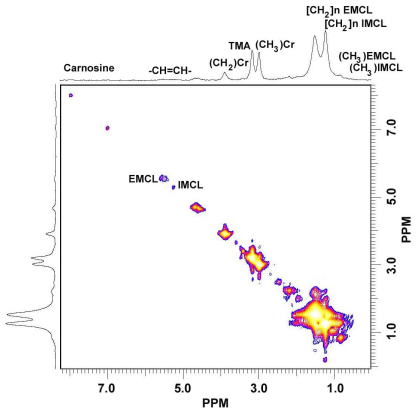


Fig 2. 2D LCT-PRESS spectrum

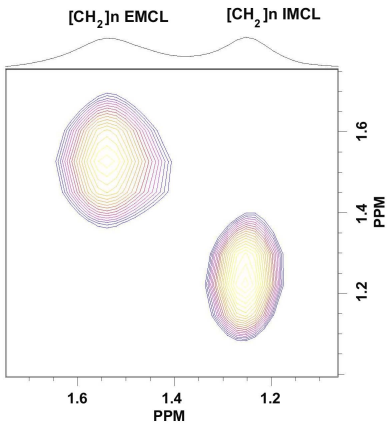


Fig 3. Expanded plot

**Discussion:** The spectral separation between the IMCL and EMCL resonances are less than 0.2 ppm in the soleus muscle (4), and therefore remain a challenge to separate at clinical field strengths. The LCT-PRESS sequence performs this separation due to its incorporation of constant-time evolution, resulting in spin-spin decoupling along the F1 dimension. LCT-PRESS is also seen to be effective in separating the olefinic components of IMCL and EMCL, which cannot be achieved by conventional approaches.

**Conclusion:** We have implemented and validated the LCT-PRESS technique in soleus muscle of healthy subjects. This sequence exhibits higher SNR due to suppression of coherence transfer, as compared to LCT-COSY. Overall, the improved resolution of IMCL and EMCL resonances permits more accurate quantification of these lipid pools.

**References:**

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