Combination of DEPT and PRESS for detection of UFA in posterior and medial thigh muscle by 13C MRS at 7T

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Introduction

The in vivo concentration and composition of unsaturated fatty acids (UFA), which are an important source of fuel in skeletal muscle, is a valid tool to assess dietary intake [1]. Although most investigations have focused on the total amount of UFA in muscle, some studies have demonstrated that the altered fatty acid contents after supplementation are different according to the specific tissues [2]. However, the low signal sensitivity of natural abundance 13C MRS which is so far the only way to detect UFA noninvasively limits the localized measurement. DEPT (Distortionless Enhancement of Polarization Transfer) SNR enhancement method is often implemented together with ISIS spatial localization [3], while the drawbacks of ISIS method especially at high magnetic field hamper the DEPT enhancement. In this work, we apply the sequence which combines DEPT and PRESS localization on protons [4] to in vivo detection of UFA. Theoretical calculation by the product operator formalism, phantom measurements and in vivo results from human thigh muscle at 7T showed that the sequence achieved sufficient SNR enhancement as well as precise localization. The UFA detected from posterior and medial thigh muscle on two healthy volunteers indicates that the sequence based on DEPT and PRESS is capable of assessing the fatty acids characterization in specific tissues non-invasively in vivo.

Materials and Methods

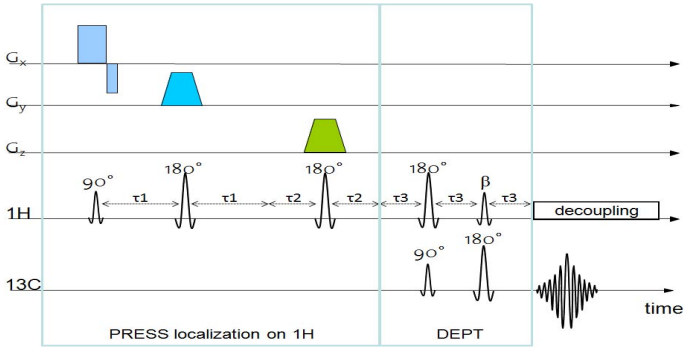


Figure 1 *Applied sequence combining PRESS and DEPT.*

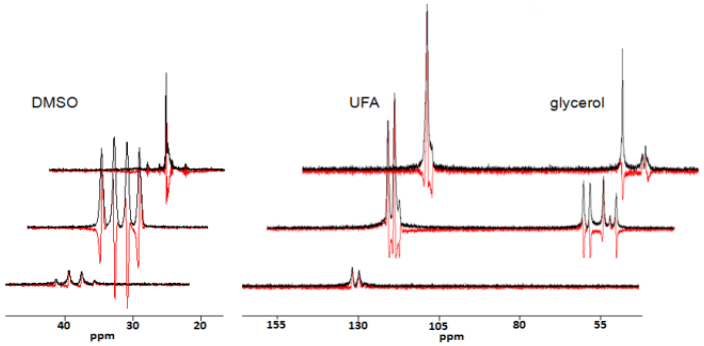


Figure 2 *Spectra of non-enhanced PRESS acquisition (bottom), PRESS-localized DEPT enhancement (middle) and PRESS-localized DEPT with proton decoupling (up) on a DMSO phantom (CH_3) (left) and thigh muscle (right).*

The conventional DEPT sequence consists of a 90°-τ-180°-τ-β pulse sequence on the I spins, combined with a 90°-τ-180°-acquisition sequence on the S spins. Two slice selective 180° pulses on I spins were inserted after the first 90° pulse to realize PRESS localization and the residual part of the DEPT sequence was implemented subsequently, as plotted in figure 1. The 180° pulses refocus the chemical shifts and the J-modulation between spins of two different nuclei, if the delays are inserted symmetrically before and after it. Therefore after the second τ_2 delay the weakly coupled two-spin system will return to the same state as directly after the 90° pulse in the absence of strong couplings and relaxation. Full SNR enhancement can be realized as the conventional DEPT sequence but the polarization transfer from protons to carbons occurs only inside a 3D PRESS localized volume. Measurements were performed on a 7T scanner (Achieva, Philips Medical Systems) using a partial volume 13C/1H human coil. The sequence was tested on a CH_3 spin system in a DMSO (Dimethyl Sulfoxide) phantom and the target CH spin system of UFA in a large thigh muscle volume. Spectra were acquired with 13 kHz BW, 8k sample points and 32 averages. Delays τ_1 and τ_2 were set to the minimum possible with regard to maximal gradient strength and pulse durations to reduce the T2 relaxation loss. τ_3 was equal to 1 / (2J) where J is the J-modulation value of the targeted metabolite. In the two-phase cycling, the original signals from 13C magnetization were subtracted by a 180° phase shift on the β pulse and the acquisition. UFA signals from two thigh muscle compartments, posterior (hamstrings) and medial (adductors) groups, were obtained and compared on two female healthy subjects.

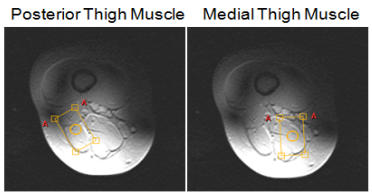


Figure 3 *UFA signals acquired from posterior and medial thigh muscles respectively on two subjects.*

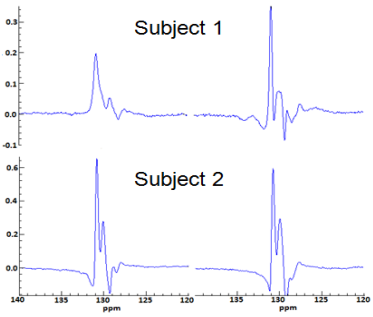
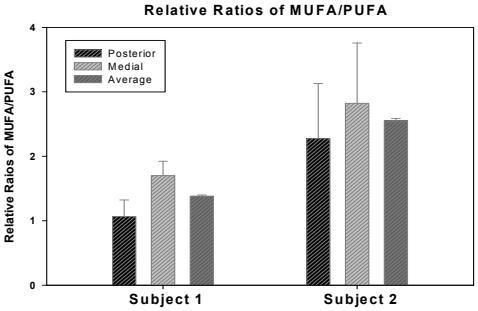


Figure 4 *Relative ratios of MUFA/PUFA in posterior, medial thigh muscles and the average.*



Results and Discussion

In figure 2 PRESS acquisition, DEPT enhancement PRESS localization and PRESS-localized DEPT with proton decoupling (from bottom to up) on a DMSO phantom (left) and a thigh muscle volume (right) are compared. On the targeted CH spin system (weakly coupled two-spin system) in phase enhancement by a theoretical factor of 4 was achieved while on the CH_3 spin system the spectra was phase distorted but still fully enhanced as expected. UFA signals obtained from posterior and medial thigh muscle compartments were shown in Figure 3. Slightly different absolute concentrations and relative ratios between mono- and polyunsaturated fatty acids (MUFA, PUFA) were found in different muscle compartments. The relative ratios which were determined by the two peak areas (peak 1 at 130ppm and peak 2 at 128ppm) of (peak 1 – peak 2)/peak 2 were plotted in Figure 4. The ratios were muscle compartments dependent and the average values were related to the dietary intakes which were within the literature value of different diets [5].

In conclusion, the sequence which combined PRESS and DEPT was implemented to achieve the first in vivo results for 13C MRS at high magnetic fields. The phantom and in vivo experiments show its feasibility to be applied to assess UFA and other metabolites of interest in specific positions.

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