THE EFFECT OF MEAL AND EXERCISE ON THE IN VIVO 31P-NMR LIVER SPECTRUM: INITIAL FINDINGS

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Introduction

Phosphorus-31 NMR spectroscopy can be used to study liver metabolism (1) and may be a useful tool in determining extent of liver fibrosis (2) and cirrhosis (3). Liver adenosine-triphosphate (ATP) can be depleted by a fructose load, with slow ATP recovery found in non-alcoholic steatohepatitis (NASH) patients compared to healthy controls, suggested to arise from mitochondrial dysfunction (1). Reduced liver ATP levels have also been observed in hepatocellular carcinoma (3). The recent epidemic rice in non-alcoholic fatty liver disease (NAFLD) demands new ways of diagnosing of NASH noninvasively, with ^{31}P-NMR spectroscopy being one potential technology. The ^{31}P-NMR liver spectrum exihibits marked changes when challenged by fructose (1) but the effects of normal daily tasks (meals, exercise) have not been determined. The objective of this study is to determine the effects of a normal high-fat meal and subsequent exercise on the ^{31}P-NMR liver spectrum in healthy subjects. Initial findings are reported.

Experimental

Subjects and design: Three healthy volunteers (one female and two males; Age 30-53y, BMI 23-25) were measured on a clinical 3.0 T MRI scanner three times during one day: i) after an overnight fast, ii) following a standardized fat rich meal and iii) following a subsequent exercise session. The standardized meal consisted of normal breakfast components constituting 72 g (65% energy) Fat, 50 g (20% energy) carbohydrate and 38 g (15% energy) protein, totaling 1000kcal. The exercise session lasted 60 minutes at a heart rate of 65 % of the individual maximum. Each measurement session lasted 1 hour, with the post-fed state measured 2 hours after the meal and the post-exercise state measured 30 minutes after exercise.

MR experiment: T1-weighted ultrafast gradient echo images were collected in three orthogonal directions with 10 mm slice thickness covering the liver. A 6x6x6 cm^3 voxel was placed in the center of the right liver lobe and proton-decoupled ^{31}P MR spectra (Fig1) were obtained using Image Selective *In Vivo* Spectroscopy (ISIS) volume selection method with TR of 6000 ms and 128 acquisitions. ^{31}P-MRS data was collected with a circular, non-flexible ^{31}P transmit-receive loop coil with a diameter of 14 cm. Body coil was used for obtaining localizer images and proton-decoupling.

Data analysis: All spectra were analyzed with AMARES (jMRUI v3.0), using prior knowledge (4,5). The ^{31}P-MRS results were expressed as a single γ-ATP resonance over the total phosphorus signal.

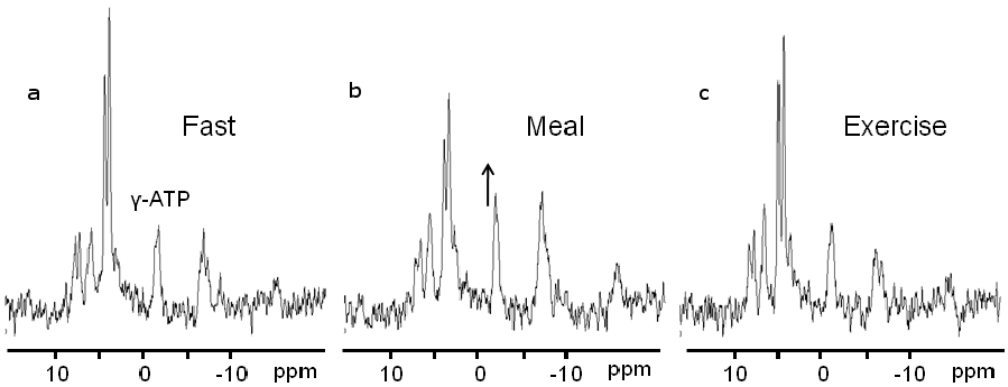

Figure 1. ^{31}P MR spectra from a single individual subject collected after a) fast, b) meal and c) exercise

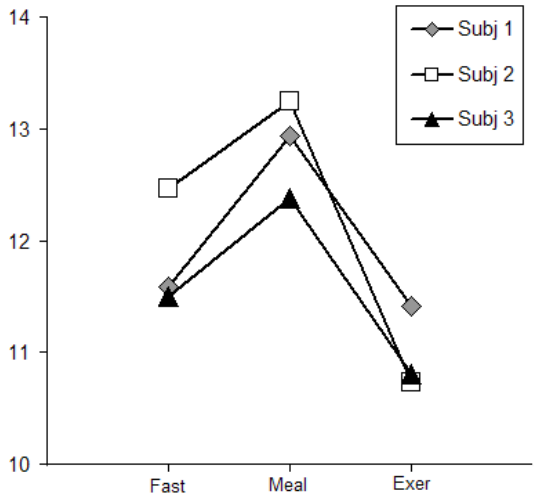

Figure2. γ-ATP/tot signal (%) of each individual.

Results

γ-ATP resonance over the total phosphorus signal was significantly higher in postprandial state (12.9±0.4; mean±SD) compared to fasting (11.9±0.5) or post exercise (11.0±0.4) states (Fig2). There were no significant differences between fasting and post exercise states.

Conclusions

This study shows a pilot data with a limited number of subjects. However, there was a trend of rising ATP resonance at postprandial state suggesting that the physiological state may have an impact and should be standardized in phosphorus studies. Also, ^{31}P-MRS can be used to determine the impact of a fat load challenge on liver metabolism.

References

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