Intramyocellular lipid (IMCL) stores before and after a fat rich diet

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Introduction
An increased intramyocellular lipid content (IMCL) as quantified by proton-MR-spectroscopy (1H-MRS) has been found to be associated with reduced insulin sensitivity (1-3). These IMCL seem to be rapidly regulated, as one single bout of exercise decreases IMCL (4), while the combination of hyperinsulinemia and elevated circulating levels of free fatty acids increases IMCL within several hours (5).

There is evidence that after the intake of fat a major part is immediately stored as triglycerides in skeletal muscle indicating an important role of skeletal muscle in the trafficking of dietary fat (6). Furthermore Boesch et al. recently reported about a diet dependent recovery of IMCL stores after exercise (7).

The aim of this study was the evaluation of IMCL stores in skeletal muscle before and after a short term high fat intake for three days.

Methods
7 male, healthy, lean subjects were examined before and after a fat rich diet (60% fat, 30% carbohydrates, 10% protein). To obtain standard conditions the volunteers were given a standard mixed diet for three days before the first examination at baseline. IMCL was then quantified by 1H-MRS after an overnight fast in the red soleus (SOL) and the mixed tibialis anterior (TA) muscle. Insulin sensitivity (IS) was assessed by a euglycemic hyperinsulinemic glucose clamp and expressed as Glucose infusion rate and Insulin sensitivity index. The measurements were done at baseline and after three days of the dietary intervention.

MR examinations were performed on a 1.5 Tesla whole-body system (Magnetom Vision; Siemens, Erlangen, Germany). Two muscles of the calf were examined, the soleus (SOL) and the tibialis anterior muscle (TA). Image guided localized proton spectra with a voxel size of 2.4 ccm were recorded from representative regions in the muscles using the standard extremity coil of the manufacturer. Volume selective shimming was performed for each new voxel position. Spectra were recorded by a STEAM technique (TR=2 s / TE=10 ms / TM=15 ms) with frequency selective water suppression. The recorded signals underwent postprocessing procedures in the time domain (Gaussian filtering with maximum at 0 ms and half maximum after 150 ms, Fourier transformation, constant and linear phase correction). IMCL signals were measured as area under the curve in fixed frequency borders (1.3-1.5 ppm) and compared to the methyl creatine signal which served as internal reference (maximum signal set to 3.15 ppm). IMCL values were calculated as ratio of IMCL and creatine signal integrals and are given in arbitrary units (a.u.). Dynamic changes are presented in % change from baseline.

Results
IMCL varied over a wide range (IMCL TA 1.8-4.6 a.u. / IMCL SOL 5.8–16.5 a.u.). After three days of the fat rich diet IMCL was significantly (p<0.05) increased in both muscles, 38% in the TA and 24% in the SOL. In contrast IS decreased by almost 30% (p<0.05). Fig. 1 shows examples of 1H-spectra of the TA (A) and the SOL (B) before and after the dietary intervention.

Discussion
The data indicate that IMCL is rapidly regulated and profoundly influenced by an oral fat rich diet. According to Besessen et al. (6) the trafficking of dietary fat leads to an augmentation of IMCL which could be directly assessed by 1H-MRS. This augmentation of IMCL in the skeletal muscle might play an important role in the dietary fat induced insulin resistance.

Fig. 1: 1H-spectra of the TA (A) and the SOL (B) at baseline (left) and three days after a fat rich diet (right). Signal peaks are indicated in A and B as Chol (choline; 3.4 ppm), Crea (creatine; 3.15 ppm), IMCL (intramyocellular lipids; 1.3-1.5 ppm), and EMCL (extramyocellular lipids; 1.5-1.7 ppm).

References

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