Effect of Weight Loss on ^{1}H MR-observed Muscle, Liver and Abdominal Fat Distribution and Insulin Sensitivity

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Introduction. MRI and MRS allow for the investigation of changes in fat metabolism by exercise/dietary intervention in liver, muscle and abdominal fat (subcutaneous (SAT) and visceral (VAT)) [1-3]. Weight loss also results in increased insulin sensitivity [4]. In this study, we investigated the changes in fat distribution pre- and post-weight loss intervention. We also determined the correlation between the changes in the fat depots and that of insulin sensitivity.

Methods. This pilot study consisted of 22 Chinese males (aged 21 to 40 years, mean weight 81.2 kg) with BMI ≥ 23 kg/m^2. Each underwent a 16-week weight loss intervention program consisting of three 90-min exercise sessions per week with expected calorie expenditure of 500 kcal per session in combination with a diet comprising of a caloric deficit of between 40% estimated total energy expenditure and 1000 kcal. Pre- and post-intervention measurements were taken which included: anthropometric measurements, metabolic profiles and insulin sensitivity index (ISI) determined using hyperinsulinemic euglycemic glucose clamp and adjusted for fat free mass (FFM). Percentage body fat was estimated using dual-energy X-ray absorptiometry (DXA). We determined IMCL and hepatic fat using ^{1}H MRS and abdominal fat using MRI on a 3T MR scanner (Tim Trio, Siemens). The spectra (Figure 1) from the liver and soleus muscle were obtained using PRESS sequence, TE/TR = 30/2000 ms and processed using LCModel [5]. The liver fat was determined from the concentration of methyl, methylene groups and unsuppressed water signal [6] and corrected for T_2 losses. Muscle fat was expressed as a ratio of IMCL to Creatine (Cr). The abdominal fat images were acquired using two-point DIXON sequence. We employed a fully automated 3D graph theoretic segmentation algorithm based on [7] to partition and quantify the subcutaneous (SAT) and visceral adipose tissues (VAT) between L1-L5 lumbar vertebrae, see Figure 3.

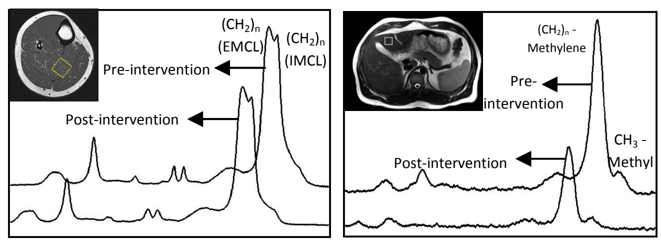

Figure 1. Typical MR spectra obtained from muscle (left) and liver (right) pre- and post-intervention.

Results. After the intervention, subjects reduced a mean weight of 6.76 kg (p=0.004), BMI decreased by 8.5% (p=0.00009) associated with an increase in ISI from 6.0 to 10.24 mg/min/kg FFM/microU/mL×10^{-2} (p=0.0001). All the fat depots except IMCL showed significant ($p < 0.05$) reduction. This can be attributed to the high metabolic activity of IMCL showing significant variation even with a single bout of moderate exercise [1] and its relatively quick replenishment rate of 15-30 hrs [8]. The reduction of fat content was greatest in the liver (54%, p=0.003), while reduction in visceral and subcutaneous fat was 32% (p=0.0004) and 23% (p=0.01) respectively. Total percentage body fat by DXA decreased by 13% (p=0.003) after weight loss. The decrease (Δ fat) in SAT, VAT and % body fat due to weight loss showed significant correlation with the increase in insulin sensitivity (Δ ISI), see Table 1.

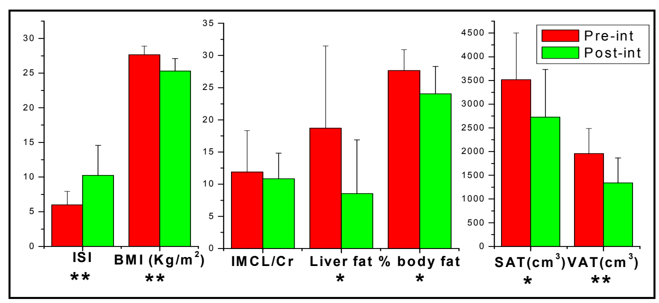

Figure 2. Differences in fat depots, BMI and insulin sensitivity pre- and post- intervention. (* p<0.05, ** p<0.001)

Conclusion. We investigated the effects of weight loss on the distribution of muscle, liver and abdominal fat and insulin sensitivity. Significant differences in all the fat depots except for IMCL were observed. The results showed that the reduction in SAT, VAT and % body fat due to weight loss were significantly correlated with the increase in insulin sensitivity.

Table 1. Correlation between Δ fat and Δ ISI (* $p < 0.05$)

Fat depot	Correlation coefficient (r)
IMCL	0.11
SAT	-0.65*
VAT	-0.55*
Liver fat	-0.25
% body fat	-0.57*

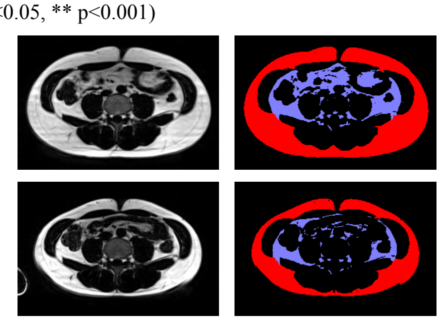

Figure 3. Typical MR abdominal images obtained pre- (top row) and post- (bottom row) intervention. Segmentation of SAT (red) and VAT (blue).

References. [1] Machann et al. MAGMA 2011; 24(1):29-33. [2] Michael et al. NMR in BioMedicine 2010; 23(5):532-538. [3] Haus et al. AJP E&M 2011; 301(3):E511-E516. [4] Bernadette et al. Obesity 2009; 19(9):1744-1748. [5] Provencher MRM 1993; 30:672-679. [6] Cowin et al. JMRI 2008; 28:937-945. [7] Suresh et al. NeuroImage 2010; 49:225-239. [8] Decombez et al. AJP Regul Int Comp Phy 2001; 281:R760-R769.