Effect of Weight Loss and Regional Differences in Abdominal Adipose Tissue Hydration

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Introduction. People with different adipose tissue morphologies exhibit varied features of metabolic disease even if they have similar degree of adiposity [1, 2]. Hyperplastic adipose tissue morphology with a large number of small adipocytes is associated with greater insulin sensitivity than hypertrophic adipose tissue morphology with fewer but larger adipocytes [2]. Currently, assessment of adipose tissue morphology requires biopsies and histological examinations of adipose tissue explants. In adult humans, weight loss results in significant decrease in subcutaneous adipocyte hypertrophy without any significant change in adipocyte number [1]. Studies using indirect measurements of subcutaneous adipose tissue water content have shown an increase in the water content following weight loss intervention [3-5]. Evaluation of adipose tissue water content could potentially provide information about changes in adipocyte hypertrophy [6]. Noninvasive methods for quantitative assessment of adipose tissue hydration have not been well established. In this study, we have investigated the use of ^{1}H MRS to quantify the changes in adipose tissue water content with weight loss intervention. Furthermore, we have looked at the regional differences in the water content in DSAT, SSAT and VAT depots pre- and post-intervention.

Methods. We studied 55 Chinese males, aged 21 to 40 years with BMI ≥ 23 kg/m^2. All underwent a 16-week weight loss intervention consisting of three 90-min exercise sessions per week with expected calorie expenditure of 500 kcal per session in combination with a diet that led to a calorie deficit of 40% estimated total energy expenditure or 1000 kcal, whichever was higher. MR abdominal images were acquired using Dixon sequence and the fat compartments (deep subcutaneous (DSAT), superficial subcutaneous (SSAT) and visceral (VAT) adipose tissues) were segmented using an automated algorithm [7]. Volume localized ^{1}H MR spectra of DSAT, SSAT and VAT were acquired at the level of the umbilicus using PRESS sequence (TE/TR = 30/2000 ms, 24 avg) on a 3T MR scanner (Tim Trio, Siemens) (Fig. 1). The size of the voxel varied from 1 to 9 cm^3 depending on the size of the adipose tissue depots. The peak resonances were fitted and quantified using in-house developed Matlab program (Fig. 1). The HLR (water/(water+fat)) was determined from the concentration of water and all the lipid peaks.

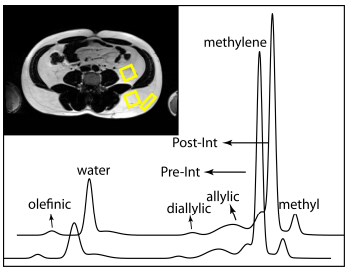

Fig. 1. Typical MR spectra obtained from abdominal fat depot pre- and post- weight loss intervention

Results. After the 16-week intervention, the subjects had a mean weight loss of 7 kg (p<0.001). The weight loss resulted in a significant reduction in the volume of all the fat depots (p<0.001) and increase in HLR (Fig. 2). The pre-intervention HLR of VAT was statistically different from that of DSAT and SSAT. However, post-intervention HLR of all the fat depots were different from each other. There was a significant negative correlation between weight loss and the increase in HLR of DSAT (ρ=-0.31, p<0.05) and SSAT (ρ=-0.30, p<0.05), but not VAT (ρ=-0.26, p=0.08).

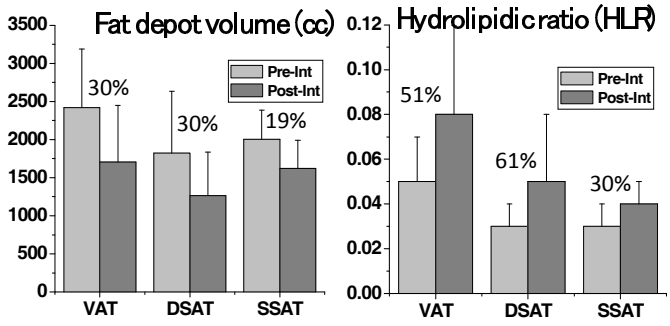

Fig. 2. Change in fat depot volume and HLR of VAT, DSAT and SSAT weight loss intervention

Conclusion. We showed that ^{1}H MRS can be used to quantify adipose tissue water content noninvasively. With weight loss, the increase in HLR in all abdominal fat depots differed, with greatest change in DSAT. Weight loss induced reduction in adipose depot volumes occurs primarily through decrease in adipocyte volume. Assessment of the tissue composition through ^{1}H MRS showed statistically significant increases in adipose tissue hydration post-intervention, which suggests that adipose tissue water content could potentially be used to noninvasively probe changes in adipose tissue morphology. There were significant regional differences in the HLR between DSAT, SSAT and VAT which indicate regional differences in the adipose tissue morphology. Pairwise comparison of the HLR of the fat depots showed significantly higher water content in VAT compared to DSAT and SSAT at baseline suggesting increased presence of hypertrophic adipocytes in DSAT and SSAT than VAT. The results provide insight into the effect of cellular heterogeneity of the different adipose tissue compartments with weight loss intervention.

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