Effect of weight loss on fatty acid composition of visceral and subcutaneous (deep and superficial) adipose tissues

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Introduction. Abdominal adiposity has a high correlation with the risks of metabolic and cardiovascular disorders. Visceral fat (VAT) is metabolically different and has a greater impact on insulin resistance than subcutaneous fat (SAT) [1,2]. In addition to the study of fat distribution in different adipose tissue compartments, there has been an increasing interest in the investigation of the composition of fat in these depots because of their association with insulin sensitivity, type 2 diabetes and cardiovascular diseases [3,4]. Magnetic resonance spectroscopy (MRS) provides a non-invasive technique to determine and quantify the fatty acid composition within the tissue. Studies have shown that the fatty acid makeup of the different fat compartments vary between each other. Upper body subcutaneous fat is more saturated than the lower body subcutaneous fat and visceral fat is more saturated than the subcutaneous fat [5]. Deep subcutaneous adipose tissues (DSAT) is more saturated than the superficial subcutaneous adipose tissue (SSAT) [6]. Weight loss intervention is known to alter the fatty acid composition of adipose tissues, with studies showing decreased levels of monounsaturated fatty acids after weight loss [7-8]. Tracking changes in fatty acid composition has required biopsies from adipose tissues. In this study, we have investigated the potential for non-invasively monitoring the changes in the fatty acid composition of the adipose tissue triglycerides due to weight loss intervention using ^{1}H MRS.

Methods. We studied 17 Chinese males, aged 21 to 40 years with BMI ≥ 23 kg/m2. Each 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 comprising of a calorie deficit of between 40% estimated total energy expenditure and 1000 kcal. Pre- and post-intervention anthropometry and metabolic profiles were measured. 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. 2). Each lipid resonance was fitted using a single Gaussian peak. The ratio of the olefinic peak (5.3 ppm) to the methyl peak (0.9 ppm) (unsaturation index, UI) is proportional to the average number of double bonds per fatty acid chain. The ratio of the diallylic peak (2.8 ppm) to the methyl peak (polyunsaturation index, PUI) is proportional to the fraction of polyunsaturated fatty acid content.

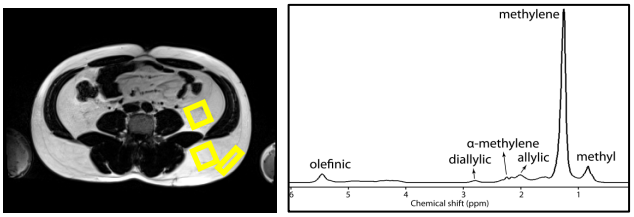

Fig. 1. Typical MR spectrum obtained from DSAT, SSAT and VAT compartments

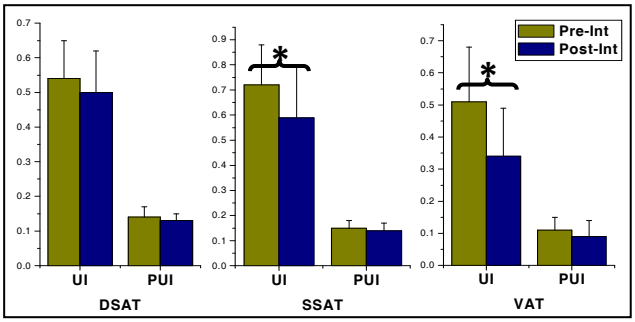

Fig. 2. Mean unsaturation (UI) and polyunsaturation (PUI) indices in DSAT, SSAT and VAT pre- and post-weight loss intervention (* p<0.05)

Results. After the intervention, the subjects had a mean weight loss of 8 kg (p<0.001). The analysis of the fatty acid composition showed that VAT had less UI and PUI than DSAT and SSAT pre- and post-intervention. Among the subcutaneous fat depots, DSAT had less UI than SSAT pre-intervention (UI: 0.54 vs. 0.72, p<0.001), but did not reach significance post-intervention. The weight loss intervention resulted in a significant decrease of UI in SSAT (0.72 vs. 0.59, p<0.05) and VAT (0.51 vs. 0.34, p<0.005). There was no significant change in PUI in all the fat depots with intervention.

Conclusion. We have determined the effect of weight loss in the fatty acid composition of adipose tissue depots. The reduction in average number of double bonds per fatty acid chain as shown by the reduction of the UI in different adipose tissue sites suggest increased mobilization of fatty acids with higher unsaturation. The selectivity of fatty acid mobilization has been shown to increase with the degree of unsaturation and decrease with the chain length [9]. The resulting enrichment of long chain fatty acids like stearic acid is favorable for insulin sensitivity [3]. We have shown that it is possible to non-invasively track the remodeling of the adipose tissue composition after an exercise based weight loss intervention using ^{1}H MRS.

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