Intra- and interindividual differences in fatty acid composition at various locations of the body assessed by ^{1}H-MRS

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Introduction

There is evidence that adipose tissue distribution in the body is involved in the pathogenesis of insulin resistance and type 2 diabetes [1]. Mainly the amount of visceral adipose tissue (VAT) is thought be a predictive factor for metabolic diseases whereas subcutaneous adipose tissue (SCAT) is often denoted to be "the protective mantle" with lower metabolic activity. However, besides the quantification of main adipose tissue compartments, there is an increasing interest in the analysis of the composition of fat. Mainly the amount of mono- (MUFA) and poly-unsaturated fatty acids (PUFA) promises new non-invasive insight in the fat metabolism of humans. Up to now, little is known about inter- and intraindividual differences in fatty acid composition in various adipose tissue compartments and its correlation to anthropometric data or the total amount of corresponding adipose tissue compartments. This study was performed in order to determine variations of fatty acid composition in multiple locations of the body.

Material and Methods

Twenty healthy male volunteers (44.6±11.5 years, BMI: 30.1±5.3 kg/m²) participated in this prospective study and underwent ^{1}H-MRS on a 3 T whole-body imager (Magnetom Trio, Siemens Healthcare, Erlangen, Germany). Spectroscopic examinations were performed in six different locations: SCAT in the neck ($SCAT_{neck}$) and in the calf ($SCAT_{calf}$), superficial (SSCAT) and deep (DSCAT) subcutaneous adipose tissue in the abdomen, yellow bone marrow in the tibia (BM) and visceral adipose tissue (VAT). Spectra were recorded applying a STEAM technique with following parameters: TE/TM/TR 20/10/4000ms, VOI between 10x12x20 and 30x30x20 mm³ depending on the location and the expansion of fat, 32-80 acquisitions depending on size of VOI, BW 1200 Hz. Post processing was performed by jMRUI (AMARES) and ratios of MUFA+PUFA (vinyl group at 5.3ppm) to methylen (CH_3 at 0.9 ppm, serving as internal reference) and PUFA (at 2.75ppm) to MUFA+PUFA were calculated. Additionally, T1-weighted whole-body MRI was performed on a 1.5 T whole-body imager (Magnetom Sonata, Siemens Healthcare) a few days prior the spectroscopic examinations for whole-body adipose tissue quantification applying a T1-weighted fast spin-echo sequence as proposed in [2]. Volumes of abdominal subcutaneous adipose tissue, VAT and subcutaneous adipose tissue in the neck (interscapular fat) were determined by an automatic post-processing procedure [3].

Results

All spectra were of excellent quality and without any water contamination from surrounding lean tissue. Even in VAT, where small inclusions of lean tissue would lead to a dominating water signal, eluding determination of vinyl-H signal, the ratio between water and vinyl-H was lower 0.3. Thus, determination of vinyl-H resonance was possible in all cases. Figure 2 presents two extreme spectra from BM (Fig. 2a, ratio 0.45) and $SCAT_{calf}$ (Fig. 2b, ratio 0.84). Fatty acids showed significantly different mean ratios of MUFA+PUFA/CH_3 with the lowest for BM (0.518) and the highest for $SCAT_{calf}$ (0.655), which is furthermore characterized by the highest coefficient of variance (CV=0.121), as depicted in Fig. 3. PUFA are highest in SSCAT (0.113) and lowest in BM (0.099). The ratio of PUFA and MUFA+PUFA is highest in VAT (0.197) and lowest in $SCAT_{calf}$ (0.160). This indicates a higher amount of poly-unsaturated fatty acids in VAT which is also significantly lower in DSCAT but not in SSCAT. There is no clear correlation neither between the amount of abdominal subcutaneous adipose tissue and vinyl-H/CH_3 of DSCAT or SSCAT nor between vinyl-H/CH_3 in the neck and interscapular fat, whereas a strong negative correlation between vinyl-H/CH_3 and %VAT (r = -0.92) was found in our cohort [4].

Discussion

Determination of composition of fatty acids in different adipose tissue compartments of the body reveals significant intra- and interindividual differences regarding the amount of mono- and polyunsaturated fatty acids. There is even a large variability in different locations of subcutaneous adipose tissue. Interestingly, yellow bone marrow has the highest variation. VAT seems to be of special interest due to the highest amount of PUFA and the strong negative correlation between %VAT and vinyl-H/CH_3. It remains unclear, whether composition of VAT is cause or consequence of an increasing accumulation of VAT. Additionally, comparison of spectroscopic results with bioptic analysis of VAT specimen should be performed in future work to validate this non-invasive approach. There are only week correlations to BMI and age. The study was limited to males in order to rule out gender related differences. Thus, further studies are needed to assess differences for different anthropometric/metabolic conditions and probable gender related differences. Changes in fatty acid composition during lifestyle intervention are of special interest and will be assessed in future longitudinal studies.

References

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3. Würslin C et al. J Magn Reson Imaging 2010; 31:430-439.
4. Machann J et al. NMR Biomed 2012; doi: 10.1002/nbm.2849.

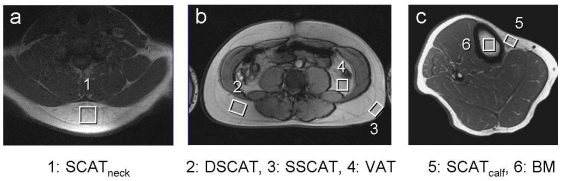

Figure 1: *axial T1-weighted images with indicated VOI for spectroscopic examinations*

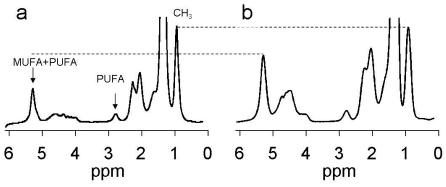

Figure 2: *Spectra from BM (a) and $SCAT_{calf}$ indicate clear differences in fatty acid composition.*

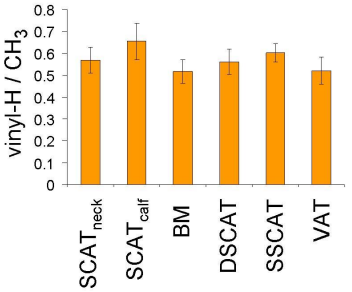

Figure 3: *vinyl-H/CH3 for the different locations indicates strong regional differences.*