Triglyceride composition measured by ^{1}H MRS at clinical field strengths

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Introduction: The study of triglyceride (TG) composition of adipose tissue has been limited by current techniques requiring an invasive biopsy. However, the multi-peak structure of the adipose ^{1}H MR spectrum (**Figure 1**) allows the TG composition be estimated non-invasively. From the diagrammatic representation of a TG molecule (**Figure 2**), the area of the spectral peaks is described by just three variables, the number of double bonds (ndb) per TG molecule, number of methylene-interrupted double bonds (nmidb) per TG molecule and the chain length (CL). The relative magnitude of each adipose peak is given in **Table 1**. As the CL of human TG varies narrowly and can be estimated at 17.5, the other two variables can be estimated by precise measurement of the five main TG peaks. Previously, use of spectroscopy to deduce human TG composition has only been applied in vivo at high field (**1**). The ability to use spectroscopy for this purpose at clinical field strength requires accurate measurements with sufficient repeatability. The purpose of this study was to determine the repeatability of MR spectroscopy at 3T to estimate ndb and nmidb in human adipose tissue in vivo.

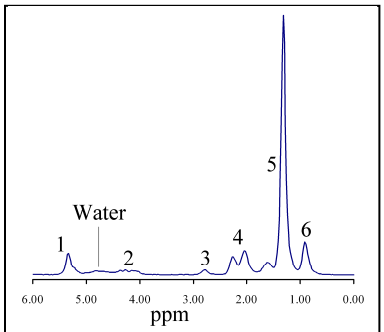

Figure 1: Typical subcutaneous adipose ^{1}H MR Spectrum

Methods: In this IRB compliant study, STEAM spectra (TR 3500 ms, TM 5 ms) were acquired on 41 human subjects at 3 Tesla (GE Signa EXCITE HD, GE Healthcare, Waukesha, WI) using an 8-channel torso array coil. After conventional imaging, a 15x15x15 mm voxel was selected in the right rear subcutaneous adipose tissue. In 8 subjects, five spectra were acquired with eight averages at progressively longer TEs of 10, 15, 20, 25 and 30 ms. In the remaining 33 subjects, spectra were acquired at a single TE (10 ms) with 16 signal averages. In all subjects two more acquisitions were obtained in the same voxel giving a total of three spectral acquisitions. Signals from different array elements were combined using an SVD technique (**2**). A single experienced observer analyzed the spectra using the AMARES algorithm (**3**) included in the MRUI software package (**4**). In the multi-TE spectra, the T2-values and the T2-corrected peak areas were calculated by non-linear least-square fitting. In the single TE spectra, the peaks were corrected for T2 relaxation using the mean T2 values found in the multi-TE spectra. To describe the triglyceride composition, ndb and nmidb were calculated by non-linearly minimizing the difference between the measured areas of peaks 1, 3, 4, 5 and 6 and that given by the theoretical model (**Table 1**). Peak 2 was not used in the calculation of ndb and nmidb, as it is a strongly coupled AB spin system. The chain length (CL) was fixed at 17.5. The results from the first measurement were compared to the second and third measurements.

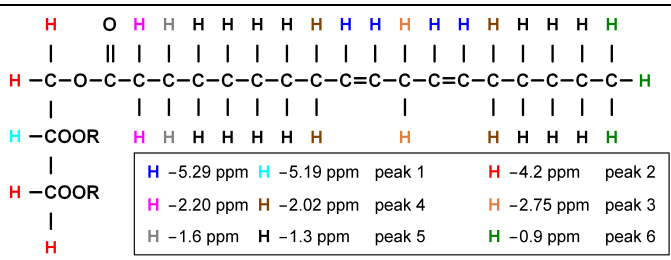

Figure 2: Diagrammatic representation of a triglyceride molecule.

Table 1: Theoretical relative magnitude of triglyceride peaks

Peak	Location	Assignment	Expected Magnitude	T2 (ms)
1	5.29 ppm 5.19 ppm	-C**H**=C**H**- -C**H**-O-CO-	2***ndb** +1	53
2	4.2 ppm	-C$\mathbf{H}_2$-O-CO-	4	-
3	2.75 ppm	-CH=CH-C$\mathbf{H}_2$-CH=CH-	2***nmidb**	54
4	2.20 ppm 2.02 ppm	-CO-C$\mathbf{H}_2$-CH_2- -C$\mathbf{H}_2$-CH=CH-C$\mathbf{H}_2$-	6 + (**ndb-nmidb**)*4	52
5	1.6 ppm 1.3 ppm	-CO-CH_2-C$\mathbf{H}_2$- -($\mathbf{CH}_2$)$_n$-	(**CL**-3)*6-**ndb***8 + **nmidb***2	69
6	0.90 ppm	-(CH_2)$_n$-C$\mathbf{H}_3$	9	93

Results: The mean T2s for the fat peaks of the multi-TE spectra is shown in **Table 1**. The ndb value estimated from the first spectral measurement is compared to the second and third in **Figure 3**, while the nmidb value estimated from the first spectral measurement is compared to the second and third in **Figure 4**. Both data show a 1:1 linear correlation (indicated by the dotted line), though there is greater variability in the nmidb value.

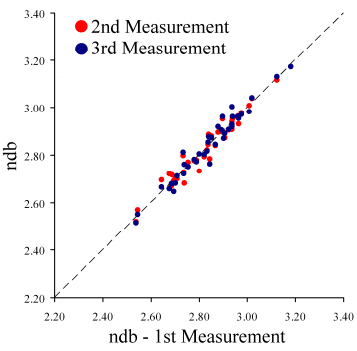

Figure 3: Comparison of ndb measured by first spectrum to that measured by 2nd and 3rd spectrum.

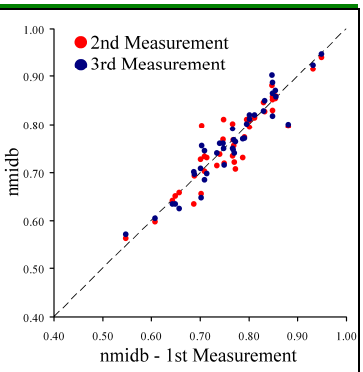

Figure 4: Comparison of nmidb measured by first spectrum to that measured by 2nd and 3rd spectrum.

Conclusions: ^{1}H MRS has high repeatability for measuring the key variables necessary to deduce triglyceride composition in human adipose tissue in vivo at clinical field strengths.

Refs: 1. Ren J, Dimitrov I, Sherry AD, Malloy CR. J Lipid Res 2008; 49: 2055-2062. **2.** Bydder M, Hamilton G, Yokoo T, Sirlin CB. Magn Reson Imaging. 2008; 26: 847-850. **3.** Vanhamme L, van den Boogaart A, Van Huffel S. *J Magn Res* **129**:35-43, 1997. **4.** .Naressi A, Couturier C, Devos JM, Janssen M, Mangeat C, de Beer R, Graveron-Demilly D. *MAGMA* **12**: 168-176, 2001.