# In vivo repeatability of liver fat measurement using $^1$H MR spectroscopy

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**Introduction:** Proton magnetic resonance spectroscopy ($^1$H MRS) is considered a gold-standard for non-invasive quantification of hepatic fat content. In most centers, spectra are collected at just one TE and consequently no information about T2 values is collected to correct for relaxation, instead assuming T2 does not vary between subjects. Omission of this information could potentially reduce the accuracy of fat quantification. We aim to examine repeatability of water T2, fat T2, and T2-corrected fat fraction given by five single average spectra collected in one breath-hold.

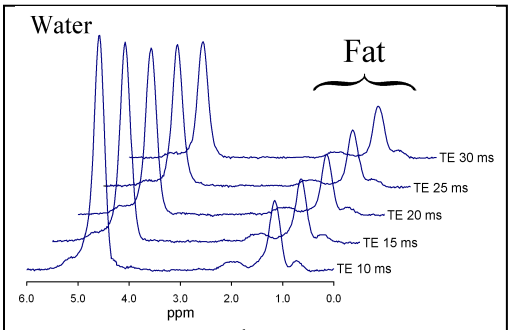


**Figure 1:** Typical liver $^1$H MRS acquisition.

**Methods:** The study was IRB and HIPAA complaint, with subjects giving written informed consent. STEAM spectra were acquired on 174 human subjects with known or suspected fatty liver, at 3 Tesla (GE Signa EXCITE HD, GE Healthcare, Waukesha, WI) using an 8-channel torso array coil. After conventional imaging, a 20x20x20 mm voxel was selected within the liver that avoided liver edges as well as large biliary or vascular structures. Following a single pre-acquisition excitation, five spectra (TR 3500 ms, TM 5 ms) were acquired with a single average at progressively longer TEs of 10, 15, 20, 25 and 30 ms in a single 21 sec breath-hold. STEAM, the short TE range, and minimum TM were all chosen to minimize j-coupling effects (**1**). This measurement protocol was repeated a total of 3 times, without changing the shim, to examine the repeatability of the measurement. 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**) and the T2 and T2-corrected peak area of the water and fat (0.5-3 ppm) peaks were calculated. The hepatic lipid values were expressed as a fraction of the 0.5-3 ppm peak area to the total peak area (water and fat). The T2s and fat fraction measured in the first spectral acquisition was compared to those values given by the 2$^{nd}$ and 3$^{rd}$ acquisitions.

**Results: Figure 1** shows the multi-TE spectra acquired from a subject with significant fat deposition during a single breath-hold. The fat fraction estimated from the first spectral measurement is compared to the second and third in **Figure 2** in all 174 subjects**.** For subjects with fat fraction > 5% (n = 93), the 1$^{st}$ water T2 measurement is compared to the 2$^{nd}$ and 3$^{rd}$ in **Figure 3** and the 1$^{st}$ fat T2 measurement is compared to the 2$^{nd}$ and 3$^{rd}$ in **Figure 4**. Dotted line indicates unity in all figures. A strong 1:1 correlation is seen in both fat fraction and water T2. However there is less evidence of agreement between the three measurements of fat T2. The mean water T2 was 22.9 ms (standard deviation: 3.6 ms) and mean fat T2 was 68.8 ms (9.2 ms).

**Discussion:** Collecting five STEAM spectra at progressively longer of TEs of 10, 15, 20, 25 and 30 ms in a single breath-hold can repeatability measure fat fraction and water T2, but not fat T2. The long T2 of fat suggests that a larger TE range should be used to measure fat T2 with higher repeatability if such measurement is needed, but for both PRESS and STEAM, increasing TE accentuates the confounding effect of j-coupling thereby reducing the accuracy of the fat T2 estimation. Importantly, as water and fat T2 show similar coefficients of variation and water T2 is far shorter, most of T2-generated variability in fat fraction is due to water rather than fat. The fat fraction is not meaningfully altered by the variability in fat T2 estimation.

**Refs: 1.** Hamilton G, Middleton MS, Bydder M, Yokoo T, Schwimmer JB, Kono Y, Patton HM, Lavine JE, Sirlin CB. J Magn Reson Imag 2009; 20: 145-152**. 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 JM3 Janssen M, Mangeat C, de Beer R, Graveron-Demilly D. *MAGMA* 12: 168-176, 2001.

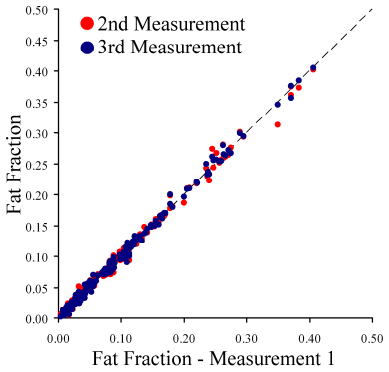


**Figure 2**: Comparison of fat fraction measured by first spectral acquisition to that measured by 2nd and 3rd acquisitions.

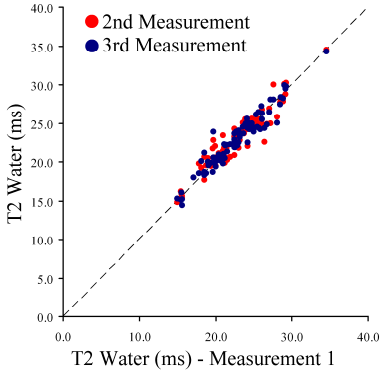


**Figure 3**: Comparison of water T2 measured by first spectral acquisition to that measured by 2nd and 3rd acquisitions.

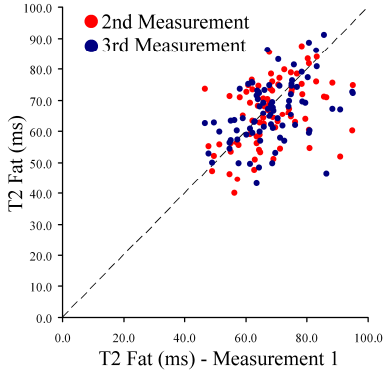


**Figure 4**: Comparison of fat T2 measured by first spectral acquisition to that measured by 2nd and 3rd acquisitions.