# Temperature sensitivity of the triglyceride fat spectral model for Dixon based fat fraction quantification

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## Introduction

Methods based on the Dixon technique are increasingly used to quantify the triglyceride fat content of the liver [1]. Since, this method usually employs a pre-defined spectral model of triglyceride fat in order to reliably separate water and fat signal in a voxel, it might be sensitive to modulations in spectral peak positions and amplitudes [2]. Temperature and local susceptibility changes are known to induce shifts of the fat spectrum with respect to the water peak [3,4] but have not yet been considered when defining the correct spectral model for Dixon based fat fraction quantification . In this study, we demonstrate the impact of temperature on the accuracy of measured fat fraction values.

## Materials and Methods

*Phantom experiments:* A water-fat phantom consisting of 9 vials (100 ml) was generated using peanut oil and agar gel. 8 of the vials had varying fat fractions (0.0 %, 5.0 %, 10.4 %, 15.8 %, 20.7 %, 32.7 %, 39.3 %, 54.3 % by mass) covering a clinically relevant range; the 9th vial contained pure oil as a reference. The amount of triglyceride fat was determined using 1H MR spectroscopy on a 3.0 T Achieva System (Philips Healthcare, Netherlands). A short-echo STEAM sequence was used where the peak intensities were individually corrected for their respective T2 decay, as measured by a series of increasing TE acquisitions. All imaging measurements were carried out on both 1.5 T and 3.0 T Achieva MR scanners. Fat fraction accuracy as a function of varying first echo times ($TE_0$) and echo spacings (ES) was determined using a multi-echo FFE sequence with 6 echoes. **1.5T:** $TE_0$: [1.16, 1.2, 1.3, 1.4] ms, ES: [0.85, 0.9, 1.0, 1.15, 1.3] ms, TR = 6.5 - 8.9 ms, FA = 5°; **3.0 T:** $TE_0$: [0.89, 1.0, 1.16, 1.3, 1.4] ms, ES: [0.6, 0.7, 0.8, 0.9, 1.0, 1.15, 1.3] ms, TR = 5.1 – 8.9 ms,
FA = 3°; voxel size = 3x3x3 mm, FOV = 375x300 mm. TR and flip angle were minimized in order to reduce T1 bias. Fat fractions were determined using an eddy current insensitive
7-peak reconstruction algorithm.
*Postprocessing:* For the phantom data, different temperatures ranging from -15 °C to 20 °C relative to the actual phantom temperature were simulated by shifting the spectral position of the triglyceride peaks in the spectral model by 0.011 ppm ·ΔT [3]. The phantom data was processed with two different spectral models, one corresponding to the human temperature of 37 °C at which the spectral model was determined and one corresponding to the temperature of the phantom (17 °C).

## Results

The fat fractions of the 9 vials according to MRS were determined as: 0.77 %, 6.60 %, 12.19 %, 17.79 %, 23.05 %, 33.58 %, 42.52 %, 55.38 %, 99.41 %. Figure 1 shows that temperature correction visibly improves the consistency of the fat fraction results over varying echo times and field strengths. The upper and lower limits of agreement are clearly reduced for 3.0T from -10.2/5.17 % to -3.53/1.79 %. Figure 2a visualizes the results of Figure 1 over a range of temperature offsets. It demonstrates that in phantom experiments the influence of the reference temperature on the determination of the spectral model is not relevant for fat fractions close to 0 % or 100 % and is most critical for fat fractions close to 50 %. Figure 2b shows that the quantities RMSE, standard deviation and bias over the range of fat fractions deteriorate by 1.8 %, 1.5 % and 1.1 % when using a wrong reference temperature with an offset of as much as 15 °C.

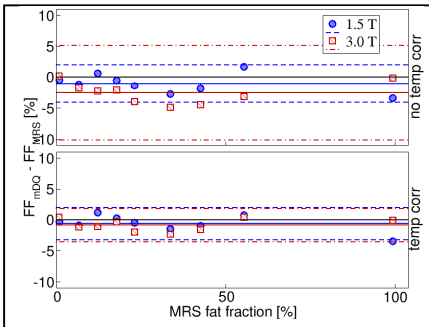


*Figure 1: Bland-Altman plots of the fat fraction accuracy measured with Dixon ($FF_{mDQ}$) vs spectroscopy ($FF_{MRS}$) in phantoms on 1.5 T (blue circles, dashed lines) and 3.0 T (blue squares, dashed-dotted lines) with (top) and without (bottom) temperature correction for a range of $TE_0/ES$ .*

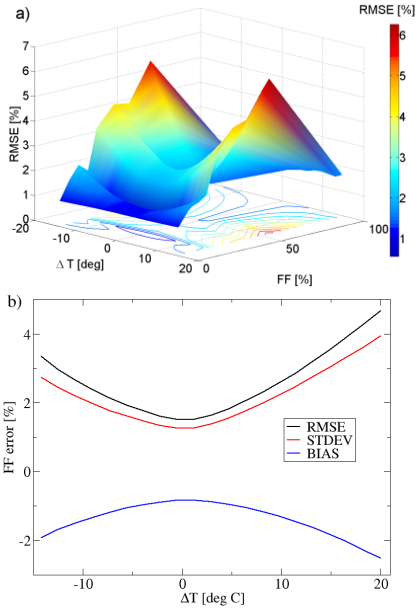


*Figure2: a) Root mean squared error (RMSE) of the measured fat fraction at 3.0 T for a range of TE0/ES as a function of the reference temperature taken relative to the temperature of the phantom. b) RMSE, standard deviation (STDEV) and bias of the data shown above combining all fat fraction values.*

## Conclusion

The measurement temperature is an important parameter when determining the correct spectral model to be used to quantify fat fractions in phantoms and in-vivo. This finding is relevant especially in the context of standardizing Dixon based fat fraction quantification methods in the future.

**References**

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