Two-component muscle T_2 quantification by maximum-likelihood estimation using an extended-phase-graph signal model with locally evaluated Rician noise

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Background: Muscle-water T_2 shows promise as a biomarker of neuromuscular diseases[1]. Fat infiltration of muscle is common in these conditions therefore multi-echo spin echo MRI signal relaxation often has contributions from both muscle-water and lipid.T2 maps are typically calculated by fitting the observed relaxation data with exponential models using least-squares (LSQ) minimization. However, the extended phase graph (EPG) formalism[2] has been shown to more accurately model such data[3], and, while it has been suggested that maximum likelihood estimation (MLE) with an explicit Rician probability density function improves accuracy when fitting exponential models to multi-echo data[4], this has not yet been demonstrated for a slice-profile corrected EPG (sEPG) model applicable to muscle T_2 measurement. We therefore investigated MLE sEPG 2-component T_2 estimation where the local noise SD is not known *a priori*.

Methods: Simulations and fitting procedures were implemented in MATLAB 2015a (MathWorks, Massachusetts, USA). 2-component sEPG signals were modelled using excitation and refocusing slice profiles calculated by Bloch simulation of the RF pulses from a multi-echo pulse sequence on a 3T Siemens Prisma system. For the data presented below, 1000 replicates were computed, at each of 3 levels of randomly generated additive Rician noise, for an echo-train with typical *in vivo* parameters T_2 30.0ms, Fat fraction (FF) 8%, excitation and refocussing flip angle 90^o and 180^o, B_1 error factor 0.9; inter-echo spacing 10ms, 17 echoes. Two fitting approaches were investigated: 1) MLE of 4 sEPG model parameters (overall amplitude, FF, T_2 and B_1) and noise SD (T_1 was fixed at 1400ms). 2) Standard LSQ estimation of the same sEPG parameters as in 1). Preliminary results fitting to *in vivo* human thigh-muscle data were also obtained.

Results: At the noise levels investigated, MLE returned T_2, FF and B_1 estimates with less bias than LSQ. MLE also successfully estimated the Rician noise SD in each case. *In vivo* sEPG-MLE FF maps compared well with independently obtained Dixon fat-fraction maps.

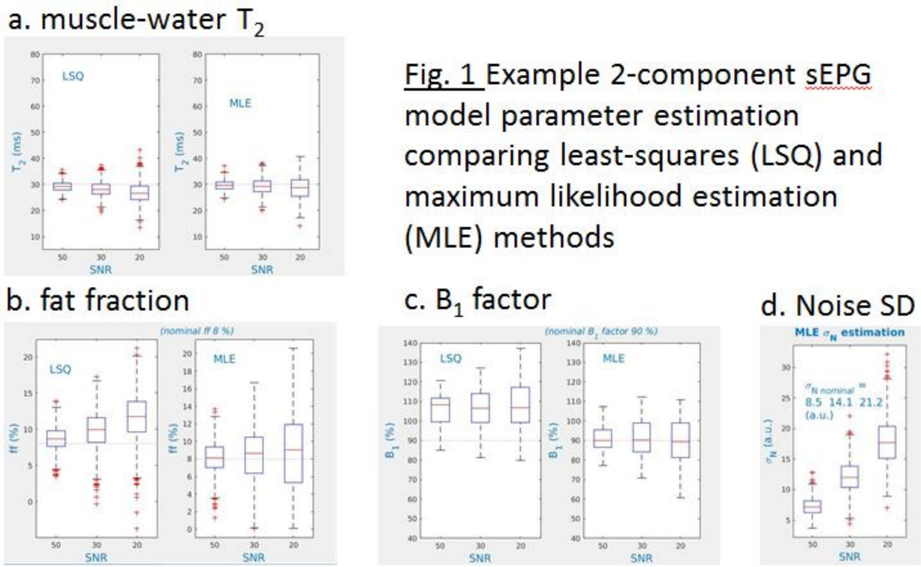

Fig. 1 Example 2-component sEPG model parameter estimation comparing least-squares (LSQ) and maximum likelihood estimation (MLE) methods

Conclusion: The sEPG model with MLE parameter estimation may offer more precise and accurate muscle-water T_2 estimation than LSQ, particularly in regions of low SNR.

References: 1. Morrow *et al.* Lancet Neurology 2016; 2. Lebel *et al.* Magn Reson Med. 2010; 3. Marty *et al.* NMR Biomed. 2016; 4. Sijbers *et al.* 1998 In: Medical Imaging'98