Whole Body Fat-Water Separation Using Multi Contrast Imaging

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Introduction

The determination of body fat content and distribution as an indicator of a number of diseases might become an interesting aspect of future whole body examination protocols. A feasibility study on this topic [1] using coronal continuous moving table imaging [2] has been previously presented. On the other hand, axial techniques [3] present a reliable and easy to handle alternative for extended field of view imaging due to less stringent requirements on hardware and post-processing. Recently, we introduced an axial multi contrast imaging approach, that allows the simultaneous acquisition of multiple datasets with various contrasts during while the subject moves continuously through the scanner [4]. Here we extend this method with the acquisition of three datasets with different TEs and a subsequent generation of metabolite maps of the whole body for fat and water using a three-point Dixon technique [5,6]. In this study three datasets of the whole body of a healthy volunteer were acquired with different TE using multi contrast imaging. Afterwards a three-point Dixon matrix inversion routine [7] was performed slice by slice on the data in order to obtain separate metabolite maps of the whole body for fat and water.

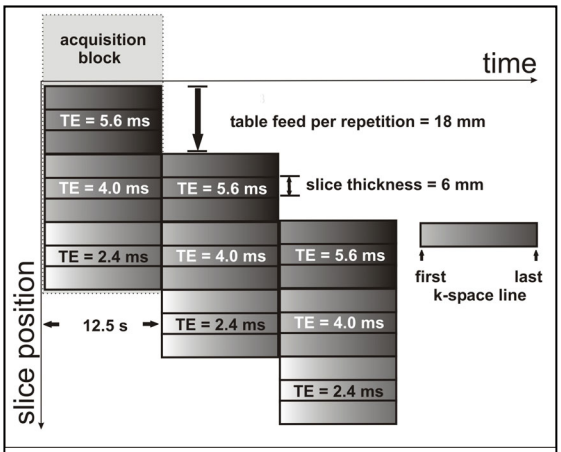
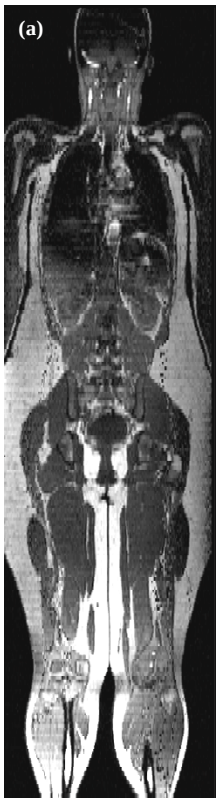


Fig 1: Triple-TE multi contrast acquisition pattern.

Method

Three datasets of different contrast were recorded in an interleaved multi slice acquisition pattern as displayed in Fig 1: Within one acquisition block, a package of 9 slices was acquired in an interleaved fashion resulting in a general TR of 71.1 ms for all slices. The acquisition block was repeated during table motion in order to cover the full FOV. The slice package was divided into three contrast sections (= 3 slices) which were acquired with a spoiled FLASH sequence at different TEs. The echo times of TE_1=2.4 ms, TE_2=4.0 ms, and TE_3=5.6 ms were adapted to phase differences of $\Delta\varphi_1$=180°, $\Delta\varphi_2$=300° and $\Delta\varphi_3$=60° between the water and fat signal. A table velocity of v_{table}=1.44 mm/s was chosen such that the table feed per repetition equals to the thickness of one contrast section. With these parameters every anatomical slice was acquired with three different TEs at time distances of $TR \cdot n_{PhaseEnc}$=12.5 s. A matrix inversion algorithm was used for the generation of fat and water only images. All measurements were performed on a 1.5 T whole body system (Magnetom Sonata, Siemens Medical Solutions, Erlangen, Germany) using local surface coil arrays and a dedicated mobile table setup (AngioSURF, MR-Innovation, Essen, Germany). Further parameters: Flip angle=45°, matrix=256x176, total FOV=40x28x162cm^3, total measurement time≈19 min.



Results

Two representative coronal metabolite maps for fat and water are displayed in Fig. 2. The fat water separation routine provided reasonable results in the central parts of the images where the magnetic field was sufficiently homogeneous. The coronal metabolite maps benefited from the high homogeneity along the z-direction provided by the axial acquisition technique. However, the quality of the fat-water separation was compromised by B_0 inhomogeneities in the outer parts of the FOV. The effect depended distinctly on the local anatomical conditions and the associated variation of B_0. This is also demonstrated in Fig 3 where the metabolite maps of an original axial slice are displayed. Free breathing lead to a spatial mismatch between the three slices to be combined resulting in artifacts in the chest and the upper abdominal regions. Furthermore, the use of stationary surface coils lead to variations in signal intensity across the axial and coronal images depending on the coil sensitivity and the distance between the coil and the chosen coronal plane.

Discussion

We demonstrated the feasibility of an axial multi contrast whole body imaging approach for fat-water separation. As all data is acquired within a single measurement procedure with only few seconds between the acquisitions of the different contrasts at any anatomical position, multi contrast imaging features a high spatial and temporal accuracy concerning belated calculation routines. However, the robustness of the technique is limited to those parts of the body that are not subject to free breathing or cardiac motion. Future improvements need also to address the loss of image quality in the metabolite maps due to B_0 inhomogeneities. The use of dynamic shim parameters and an iterative Dixon reconstruction approach [8] that estimates the B_0 inhomogeneities are currently under investigation.

Fig 2: Coronal metabolite maps for fat (a) and water (b) after Dixon-reconstruction. ➡

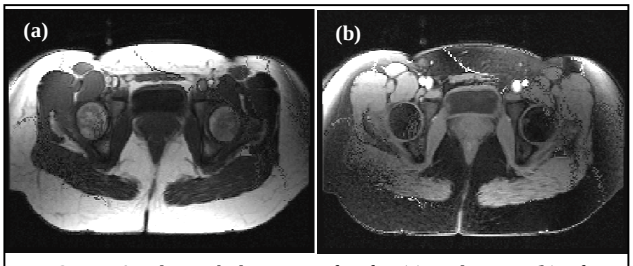


Fig 3: Axial metabolite maps for fat (a) and water (b) after Dixon-reconstruction.

References

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