Fast Whole-Body 3D Water/Fat Scoring

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Introduction

The amount and distribution of body fat is linked to a number of obesity-related illnesses, e.g. diabetes and diseases of the circulatory system [1]. Clear knowledge about these parameters may help to improve diagnosis and therapy or help to judge potential risks for the individual patient. Whole-body 3D head-to-toe water/fat selective MR imaging can thus be of interest for clinical practice. Imaging can be done very efficiently using 3D continuously moving table techniques [2-4], which allow fast whole-body scanning at high patient comfort. Moderate spatial resolution would be sufficient for this kind of examination, thus the required scan time can be short. For water/fat signal separation, a three-point-Dixon chemical-shift-encoding approach [5] is advantageous because of its insensitivity to local resonance frequency variations caused by the body's susceptibility. This new fast whole-body fat scoring approach was investigated in an initial study on healthy volunteers. Using simple image-processing algorithms, useful information was derived that could be of interest for clinical diagnosis.

Methods

In-vivo experiments were performed on 5 healthy adults (male, 18-36 years), using a 1.5T whole-body scanner (Achieva, Philips Medical Systems). The body coil was used for RF transmission and signal reception. The patient table was moved during data acquisition at constant velocity controlled by an external PC. Continuously moving table data acquisition was performed using an isotropic 3D gradient-echo pulse sequence with lateral frequency-encoding direction [4]. A fly-back EPI-type gradient-echo sequence was used with a linear 3D *k*-space sampling scheme. After one RF excitation, three identically phase-encoded gradient echoes were acquired at the same read-out gradient polarity to avoid eddy-current related problems. The first TE was set to 1.6 ms, the TE increment to 1.2 ms and TR to 5.9 ms. The flip angle was 10°, the elementary FOV in motion direction 128 mm, the virtual FOV 512 ×2000 ×294 mm³, the voxel size 6.4 ×6.4 ×6.4 mm³, the table velocity 16.5 mm/s and the total scan time 2 minutes. During reconstruction, data were corrected for table motion and Fourier transformed, yielding three 3D data sets corresponding to the individual echo times. Iterative water/fat separation was performed by fitting the local B_0 inhomogeneity as an additional parameter [5]. Based on the 3D water and the 3D fat images obtained, a simple data analysis was performed. As examples of data to be extracted, the total water-to-fat body ratio, the weight (assuming a body fat density of 0.94 g/cm³), height and body-mass index (BMI) were estimated. Using user-guided segmentation, the ratio of intraperitoneal/extraperitoneal (inside/outside the abdominal chamber) fat was determined as well.

Results and Discussion

Figure 1 shows central slices from the isotropic 3D fat/water data sets of two selected volunteers, and additionally the total water and fat projections as functions of *z*. These data illustrate the usefulness of 3D continuously moving table imaging for fast head-to-toe water/fat selective imaging. Excellent water-fat separation is achieved, and no moving-table imaging artifacts are visible. Parameters extracted from the 3D data are summarized in the table. The global water/fat ratio may be a simple but interesting parameter. More costly from the processing point of view was the determination of the intra/extra (i/e) peritoneal fat ratio. This parameter reflects the bio-distribution of abdominal fat, inside/outside the abdominal chamber, which is generally considered diagnostically relevant. The body height and weight derived in this initial study are in rather good agreement with their conventional measures (given in brackets), showing that these parameters including the BMI can be derived from MRI directly. Additional useful information could be extracted from the measured data by the use of more advanced image-processing algorithms.

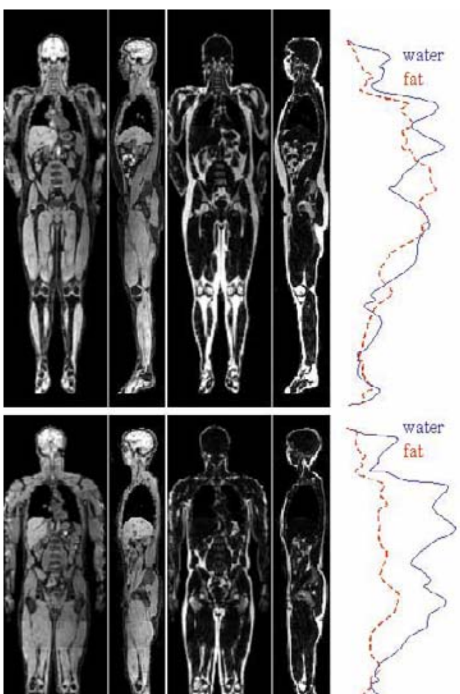

Fig. 1. Selected views of the isotropic 3D water/fat data sets of two volunteers. The curves show the projections, f(*z*), for water and fat.

volunteer	water/fat	peritoneal fat (i/e)	weight (kg)	height (cm)	BMI
#1	2.11	0.39	81 (80)	183 (184)	24
#2	2.04	0.36	80 (80)	179 (180)	25
#3	1.17	0.49	88 (85)	174 (173)	29
#4	1.32	0.42	83 (84)	174 (174)	28
#5	1.71	0.50	77 (73)	180 (180)	24

The parameters extracted so far will not change diagnostic procedures, but they show the basic potential of this fast head-to-toe scan. Provided more elaborate image processing is available to extract the desired information, this type of scan could in the future be added to each MRI exam because of its rather short total duration and the high patient comfort due the continuously moving table technology.

Conclusion

3D whole body water/fat sensitive screening can be performed using continuously moving table imaging with high efficiency. The three-point Dixon approach was found to be robust and efficient. Due to its short total duration, this type of scan could easily be added to each clinical protocol. However, further improvements in data analysis are mandatory.

References

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