Volumetric adiposity imaging over the entire abdomen and pelvis in a single breath-hold using IDEAL at 3.0T

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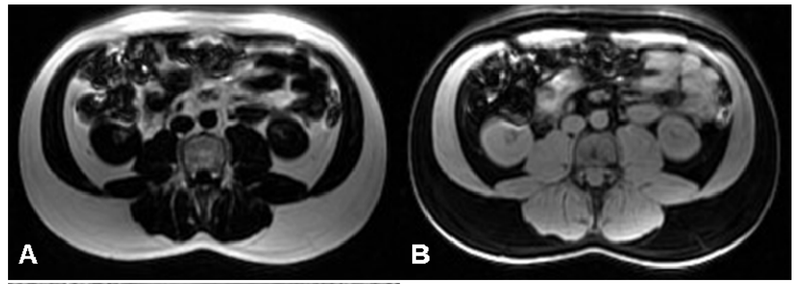
INTRODUCTION. Volumetric quantification of visceral and subcutaneous adipose tissue depots (VAT and SCAT) is a potentially useful tool for risk assessment in patients with metabolic syndrome and related disorders [1-5]. However, accurate and reproducible quantification of adipose volumes using CT [3] requires unnecessary exposure to ionizing radiation. T1-weighted MRI methods for adipose quantification are safer, but involve tedious manual segmentation of the fat depots, resulting in imprecise volume estimation [4, 5]. Chemical-shift based fat-water imaging methods greatly facilitate segmentation [6-9], but long acquisition times for complete coverage of the entire abdomen and pelvis require multiple-breath-hold acquisitions which may suffer from misregistration. In this work, we seek to address these limitations by introducing an advanced chemical-shift MRI technique for acquiring volumetric 3D adipose images over the entire abdomen in a single breath-hold.

METHODS. All MR images were acquired on a clinical 3.0 T MRI scanner (MR 750, GE Healthcare, Waukesha WI) using a 32-channel phased-array body coil (Neocoil, Pewaukee WI). Fat and water images were obtained in a single breath-hold using a modified iterative decomposition with echo asymmetry and least-squares estimation (IDEAL) technique with a 3D multi-echo spoiled gradient-echo (SPGR) pulse sequence [7], with low flip angle of 3^{O} to minimize T1-weighting bias [10]. The modified IDEAL technique employed spectral modeling of the fat signal for more accurate fat-water separation [11] and corrections for T2* decay [12] and eddy current-induced phase shifts [13]. After IRB approval and informed consent, ten normal volunteers were scanned in a supine position, acquiring 60 axial 8 mm slices with a 224x160 matrix over a 44 cm x 33 cm FOV, for true spatial resolution of 2.0 mm x 2.1 mm x 8.0 mm. The acquisition protocol had TR = 8.9 ms, 4 echoes/TR with echo spacing = 1.6 ms, and BW = ±200 kHz. Scan time was 24 sec with 2D auto-calibrating parallel imaging (ARC) [14] to accelerate the acquisition by a net factor of 2.7, using a 24x24 elliptical central calibration region. Online reconstruction was performed using a region-growing algorithm [15] providing separate water, fat and fat-fraction (F/(W+F)) images via a magnitude discrimination technique to minimize noise bias [10].



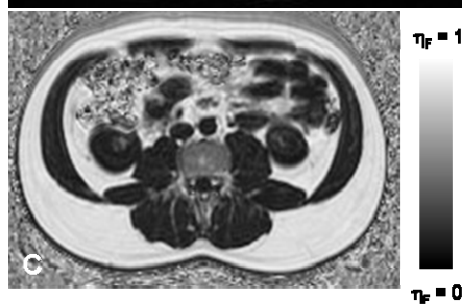
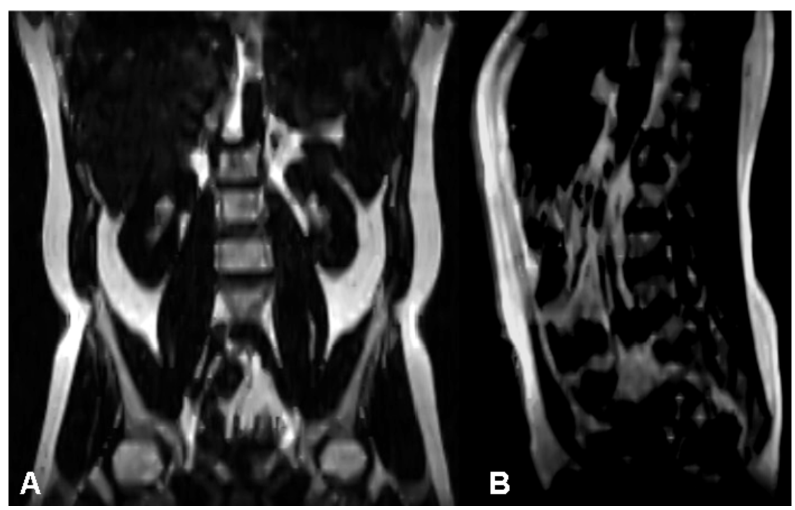


FIGURE 1 (above): Axial images of a. fat, b. water, and c. fat-fraction.

FIGURE 2 (below): Reformatted fat image in a. coronal and b. sagittal views.



RESULTS. Figure 1 shows high-resolution fat, water, and fat-fraction axial images from a male subject. Despite the large acquisition volume, the fat-water separation quality is consistent from the dome of the liver to the base of the pelvic floor. Figure 2 provides a better sense of the total anatomic coverage, by showing coronal and sagittal views of the VAT and SCAT depots which greatly facilitate manual segmentation.

DISCUSSION. We have demonstrated the capability to acquire high-spatial resolution 3D volumetric images of the entire abdomen and pelvis, using a highly-accelerated chemical-shift-based water-fat separation technique and a 32-channel coil at 3.0T. The high-quality fat and fat-fraction images obtained by this technique provide unprecedented visualization and delineation of the adipose depot boundaries, with sufficient spatial resolution to allow 3D reformatting for optimal segmentation. This new technique will greatly facilitate rapid quantitative assessment of visceral adipose tissue volume, VAT/SCAT ratio, and total adipose volume within a single-breath-hold acquisition without the need for ionizing radiation.

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