Quantification of abdominal subcutaneous and visceral adipose tissue using a 3D CAIPIRINHA DIXON VIBE acquisition and automated segmentation

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Purpose: Obesity and related diseases are a serious health problem in Western countries. Measures of visceral and subcutaneous adipose tissue (VAT/SCAT) are useful tools for stratifying risk in these individuals. MRI measures of VAT and SCAT are typically obtained from T1-weighted gradient images segmented manually, or semi-automated from thresholded images (1-3). Here we present an optimized strategy for fast acquisition of abdominal fat images using a 3D- CAIPIRINHA DIXON VIBE acquisition (4) and automated quantification of SCAT and VAT using a pixel connectivity mapping approach.

Methods: Five volunteers (BMI: 27± 4.2kg/m^2) were scanned using a 3D-CAIPIRINHA DIXON VIBE and standard T1 weighted 3D DIXON VIBE sequences. The order of sequences was randomly assigned and each was acquired in a breathold. Imaging parameters were identical for the two sequences except for total acceleration factor of 4 for CAIPIRINHA. 72 axial in-phase, out of phase, fat and water images with FOV: 380x310 mm; slice thickness: 3mm; TR: 3.97ms; TE: 1.29 & 2.52ms; voxel size 1.2 x1.2x3mm^3 and 1 NEX were obtained. Images were traced manually and using the automated methods to delineate VAT and SCAT (Figure1). For consistency, spine was not segmented separately. For automated analysis, a threshold based on the mean and standard deviation of the pixel signal intensity of each slice was applied to convert the gray-scale data to a binary image. Next using pixel-connectivity mapping the subcutaneous and visceral fat areas were identified as separate objects in each image. Further morphological operations, such as image dilation and erosion, were required to correct for pixels in the visceral fat area mislabeled as subcutaneous fat pixels. A mask image was created with pixel intensity of one for subcutaneous fat, and a value of two for visceral fat. Intra class correlation and Bland-Altman Analysis was used to compare the automated and manual segmentation of VAT and SCAT.

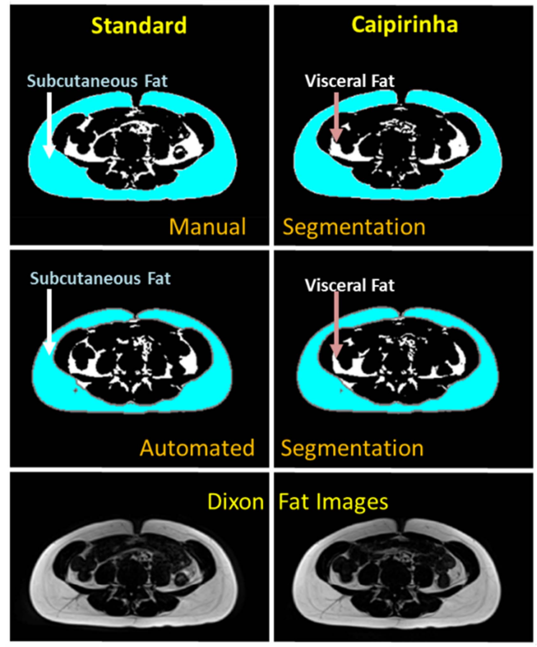

Figure 1: Automated (middle row) and manual segmentation (top row) of fat images obtained using standard 3D DIXON VIBE(left column) and 3D DIXON VIBE with CAIPIRINHA acceleration (right column). Bottom row shows fat images obtained from scanner.

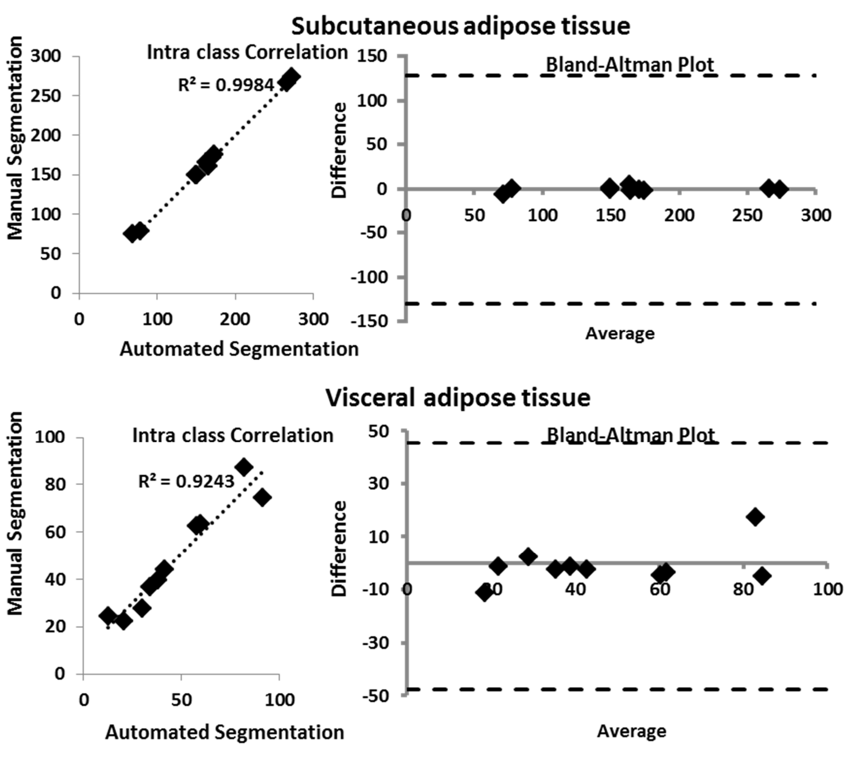

Figure 2: ICC (left) and Bland-Altman (right) plots showing differences in quantification of SCAT(top) and VAT(bottom)using manual and automated segmentation approaches

Results: Acquisition time for CAIPIRINHA was 15 seconds compared to 40 seconds for standard 3D DIXON VIBE. Qualitatively, image quality was indistinguishable between the two acquisition methods. Average image analysis time was significantly shorter for automated segmentation of the entire acquired volume (1029±118 seconds for manual segmentation vs. 27±13seconds for automated method, $p < 0.01$). Figure 2 shows the ICC and Bland-Altman results indicating excellent agreement between the manual and automated segmentation.

Conclusion: The presented approach provided a reliable and fast image acquisition for MRI-based fat quantification with automated segmentation providing a faster analysis.

References:

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(3) BonekampInt et al J Obes 2008
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