Multi-site transferability of image analysis methods for assessing visceral adipose tissue by MRI

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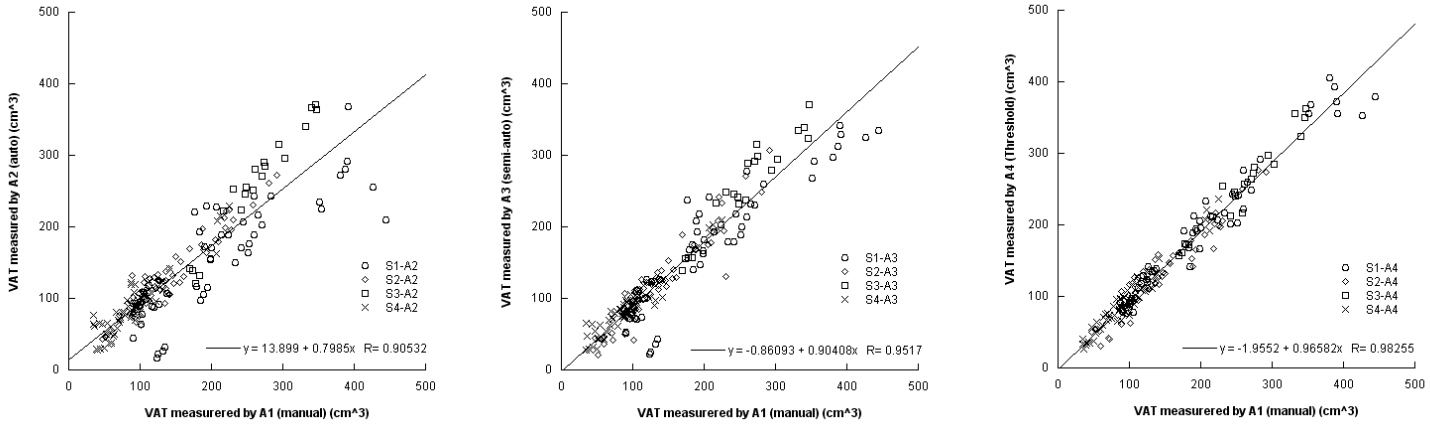
Introduction: MRI represents the best diagnostic tool for assessment of subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT), that are important risk factors in several metabolic diseases and cardiovascular pathologies. Several image processing algorithms were developed and validated for fast assessment of adipose tissue distribution [1,2]. In particular, VAT assessment is a challenging task due to complex structure of viscera. Commonly used methods for VAT evaluation are manual VAT delineation and automatic or semi-automatic segmentation based on histogram values or a user-defined threshold. Aim of this study is to verify the transferability of these different image processing approaches among images acquired with different scanner and sequences.

Materials and methods: Images from 50 patients acquired at four MRI sites (Table 1) were retrospectively analyzed. Four transverse, T1-weighted axial slices covering the space between L4 and L5 were used to define VAT. Mean contrast-to-noise ratio (CNR) between fat and non-fat tissue was evaluated for each site. Signal homogeneity was evaluated as the standard deviation of fat signal among four ROIs traced at the four corners of SAT.

Table 1: Patient population and acquisition parameters

Site	# Patients	Scanner	Seq	Thick.	Matrix	FA	TE	TR	CNR	Homogeneity
S1	12	Siemens Sonata 1.5 T	GRE	5 mm	256x256	80°	4.6 s	130 s	3.2±0.5	35.1±4.6
S2	18	Elscint Prestige 2.0 T	SE	6 mm	256x256	120°	12 s	500 s	11.3±1.5	68.2±7.2
S3	5	Philips Intera 1.5 T	GRE	5 mm	256x256	90°	4.6 s	135 s	13.2±1.7	13.2±2.4
S4	15	GE Signa 1.5 T	GRE	5 mm	256x256	90°	4.2 s	120 s	14.7±2.1	15.9±3.1

Images were analyzed following four approaches: A1: fully manual analysis using ImageJ (VAT delineation by mouse and by magic wand selection tool) [1]. A2: Fully automatic analysis using HIPPO FAT tool (fuzzy c-mean algorithm joined with active contours to detect a region including all VAT; VAT extension was calculated by evaluating the area of the Gaussian curve that was previously fitted at second peak of the grey level histogram of the detected region) [3]. A3: Semi-automatic analysis using HIPPO FAT (like A2 with manual correction of contours and histogram fitting). A4: Threshold based VAT segmentation with interactive selection of the best threshold value for each image by visual inspection. Time required for image analysis was also recorded.



Results: Figure shows the relationship between VAT measurements performed by A2, A3, and A4 methods respect to the manual A1 approach taken as gold standard. All method showed a high correlation with manual approach. The best correlation (r=0.98) was obtained by threshold method (A4). Histogram fitting based methods (A2 and A3) mainly failed when applied to images with low CNR (S1 site). Threshold based method was less affected by this problem. Signal homogeneity did not significantly affect the analysis results. The mean time required for analysis of one patient was 40 min for A1 method, 8 min (without user interaction) for A2, 24 min for A3, and 20 min for A4.

Discussion: Available comparisons of algorithms for fat assessment in MRI are limited to data sets from a unique site/scanner. In this study four sites/scanners were involved to assess image quality dependence of four different image analysis approaches. For images with high fat/non-fat CNR all methods are interchangeable and strongly correlated. Automated analysis is reliable and save analysis time. For images with low CNR the threshold based method (A2) should be preferred. Signal inhomogeneity, that was demonstrated important in SAT evaluation [4], seems to not significantly affect VAT measurements.

References: [1] Bonekamp Int J Obesity 2008;32 :100-111 [2] Demerath EW et al. Int J Obes 2006; 31(2):285-91 31(2):285-91 [3] Positano V et al. JMRI 2004;23(5):662-668 [4] Positano V et al. JMRI 2008;28(2);403-410.