**Validation of Fully Automated Segmentation of Visceral Adipose Tissue from Whole-Body Continuously Moving Bed MRI**

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## Introduction

Both the amount and distribution of adipose tissue, especially the amount of intra-abdominal or visceral adipose tissue (VAT), are related to many types of diseases [1, 2]. Fast whole-body imaging for assessment of adipose tissue depots might therefore be of interest in many areas of medical research. The feasibility of whole-body fat and water imaging using multi-echo acquisition and continuously moving bed imaging (COMBI) has previously been presented [3]. This acquisition is fast, gives good adipose tissue contrast, and allows absolute quantification of fat and water content [4]. Manual segmentation of different adipose tissue depots is time consuming and operator biased. Automation of this process allows reduction of analysis time and bias. However, to the author's knowledge, no method has previously been presented for fully automated segmentation of VAT from whole-body MRI datasets.

## Methods

Whole-body COMBI fat and water imaging of ten volunteer subjects (seven males, three females, age 20-62 years, BMI 22.1-33.3) was performed using a 1.5T clinical scanner (Achieva; Philips Medical Systems, the Netherlands) modified to allow arbitrary table speed. Subjects were imaged in supine position with the arms extended above the head. The body coil was used for RF transmission and signal reception. A multi-echo 3D gradient echo imaging sequence was used. Imaging parameters were: TR 5.9 ms, TE 1.36/3.22/5.09 ms (same read-out gradient polarity was used to avoid eddy-current related problems), flip angle 3 degrees, elementary FOV (in motion direction) 112 mm, virtual FOV 530x377x2000 mm³, reconstructed voxel size 2.1x2.1x8.0 mm³, and table velocity 6.5 mm/s. The total scan time was 5 min 15 sec.

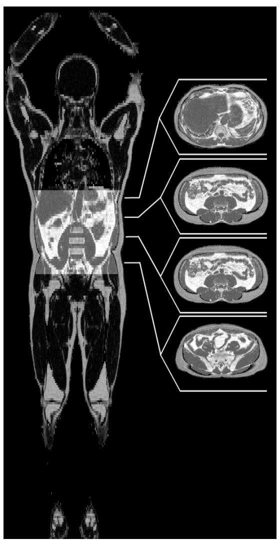

Figure 1: Binary mask illustration

The fully automated VAT segmentation algorithm utilizes the magnitudes of both the reconstructed fat and water MR signal components and the fat and water fractions derived from these magnitudes. These images are hereafter denoted fat, water, fat fraction, and water fraction images, respectively. The subvolume of the abdomen is defined by the volume between two levels, in feet-head direction. The lungs and the femur heads are used to determine the upper and the lower level, respectively. Lungs are segmented by use of thresholding of voxels with low intensity from the sum of the fat and water images in combination with morphological operations. The level in feet head direction where 95% of the segmented lung volume is excluded determines the upper level. A maximum intensity projection, in anterior-posterior direction, of the water fraction image is used to locate the crotch of the subject. To locate the femur heads, a template was fitted to the image data. The template was created from a smoothed subvolume of the femur head from the water fraction image of one subject (not included in the study). The position of the crotch was used as reference point. A binary mask is created in the abdominal subvolume to exclude subcutaneous adipose tissue from the abdominal subvolume, see Figure 1. The mask is created using the water fraction image processed using thresholding, morphological operations, filtering of the largest binary object, and convex hull creation. The volume of VAT is defined as the volume of all voxels within the binary mask with more than 50% fat fraction. Results from manual segmentation of the VAT depot from the fat image, performed by an experienced operator, were used as reference. The region of the VAT was manually delineated and the voxels with fat fraction above 50% were included in the final VAT volume.

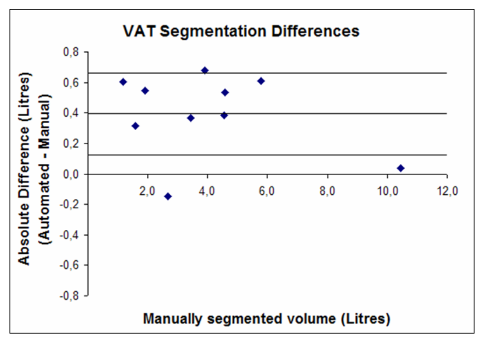


Figure 2: Difference between VAT segmentation methods (Automated-Manual) plotted against the results from the manual measurements. The lines illustrate difference mean and ± 1 standard deviation.

## Results and Discussion

The difference between the automated and the manual measurements of VAT are shown in Figure 2. The automated method is seen to overestimate the amount of VAT in many subjects. The inclusion of bone marrow was seen to be the main reason. The amount of correctly segmented and over-segmented voxels was found to be 92 ± 2.8%, and 23 ± 14% of the amount of reference VAT voxels, respectively. The algorithm performance needs to be evaluated using more subjects and automated exclusion of bone marrow, possibly by locating pelvis and spine using a priori information, would be advantageous.

## Conclusion

A fully automated algorithm for segmentation of VAT from whole-body fat and water images acquired using moving bed MR imaging is presented. The acquisition and post processing technique presented will likely be of great use in obesity related studies. The results can likely be improved further by exclusion of bone marrow.

## References

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