Reproducibility of Fast Whole-Body Assessment of Adipose Tissue Depots from Continuously Moving Bed MRI

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Introduction

The epidemic proportions of overweight and obesity in many countries have increased the need for fast and accurate assessment of body composition for studies of pathophysiology and new treatment regimes. Both the total amount of adipose tissue (TAT) and its distribution, especially the ratios of intra-abdominal or visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT), are related to many types of diseases [1]. The imaging modalities Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) have been concluded to give the most accurate body composition results [2]. CT is known to provide fast and accurate area and volume quantification but radiation exposure limits its use in assessment of body composition. MRI can be used, without any known side-effects, in combination with continuously moving bed imaging (COMBI) to generate high quality fat and water images from the whole-body region within a reasonable amount of time [3]. Manual analysis of these amounts of image data is time consuming and biased by the operator. Fully automated analysis removes operator bias and allows time efficient analysis.

Research studies rely on calculations of study group sizes. These calculations require accurate knowledge of the total method variability. This variability is measured in reproducibility studies. A segmentation algorithm that allows fully automated assessment of the total amounts of TAT and abdominal VAT and SAT from fat and water images acquired using COMBI MRI has been developed. The reproducibility of these measurements has previously not been investigated.

Methods

Repeated whole-body COMBI fat and water imaging of nine volunteer subjects (six 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. The subjects got off the table and had a short break between the repeated acquisitions. 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 COMBI sequence [4] 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 for one whole-body acquisition was 5 min 15 sec. Based on these 3D data fat and water separation was performed using an algorithm previously described [5][6] with only minor adjustments.

The fully automated segmentation of the adipose tissue depots utilizes the magnitudes of both the separated 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. The adipose tissue volumes were defined from segmented whole-body and abdominal volumes as the volumes of voxels with a fat fraction above 50%. The whole-body volumes were segmented using thresholding of the summed water and fat magnitudes in combination with morphological operations. The intra abdominal volumes spanned a region limited in feet-head direction by the lungs and the head of femur. These were automatically located using basic image processing tools like morphological operations and template based searching. The water fraction image was then used to create a binary mask which allowed separation of abdominal VAT and SAT.

Results and Discussion

The absolute differences between the two measurements of TAT, VAT, and SAT are shown in Figure 1. The absolute/relative differences were found to be: TAT: -0.24 ± 0.37 litres / -0.90 ± 1.26 %, VAT: 0.07 ± 0.11 litres / 1.60 ± 4.12 %, and SAT: 0.05 ± 0.22 litres / 0.67 ± 3.07 %. The automated segmentation of TAT and VAT does not exclude bone marrow from the analysis. Automatically segmented VAT volumes have previously been found overestimated compared to manually segmented volumes in many subjects.

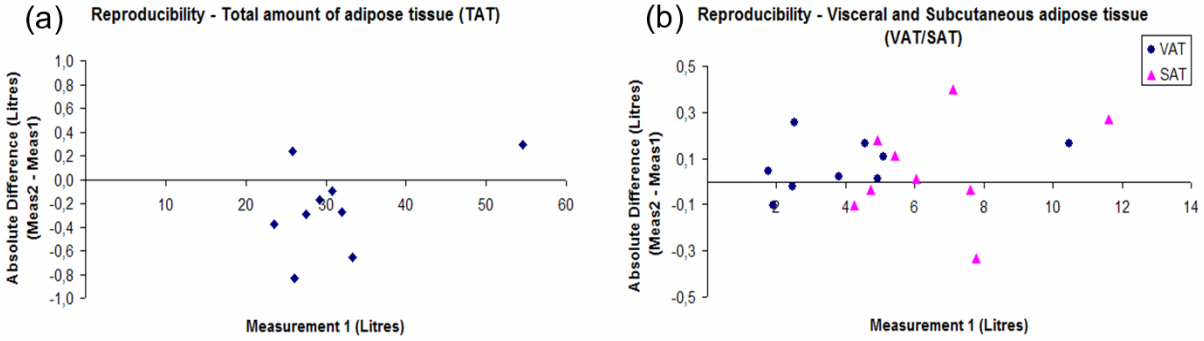

Figure 1: The absolute differences between the two measurements (Meas2 – Meas1) versus the volumes from the first measurements for total adipose tissue (TAT, Figure 1a), visceral adipose tissue (VAT, Figure 1b), and subcutaneous adipose tissue (SAT, Figure 1b), respectively.

Conclusion

Reproducibility data from automated analysis of TAT and abdominal VAT and SAT from repeated whole-body COMBI MRI acquisitions is presented. The small deviations found between the repeated measurements suggest a substantial value in this rapid acquisition and automated analysis technique, allowing longitudinal obesity related studies in large patient cohorts.

References

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