MRI Compared to CT in Whole-Body Slice Area Measurements

J. Kullberg[1], J-E. Angelhed[2], J. Brandberg[2,3], H. Frimmel[1], E. Bergelin[2], L. Strid[2], H. Ahlström[1], L. Johansson[1], L. Lönn[2,3]

[1]Department of Radiology, Uppsala University Hospital, Uppsala, Sweden, [2]Department of Body Composition and Metabolism, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden, [3]Department of Radiology, Sahlgrenska University Hospital, Göteborg, Sweden

Introduction

The increase of overweight and obesity in the western world indicates the need for accurate body composition analysis assessing both regional and whole-body adipose tissue. Imaging is needed to accurately assess the large inter individual variability in adipose tissue amount and locality. The imaging modalities Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are considered to give the most accurate results. MRI can be used to image the whole-body volume within a reasonable amount of time without any known side-effects. CT is known to provide fast and accurate area and volume quantification but radiation exposure limits the total number of imaged slices. Adipose tissue has been analysed using MRI and CT in many studies, however, to our knowledge MRI has not been compared to CT in whole-body analysis. In this study total slice area accuracy, distributed over the whole body, of a gradient echo MRI sequence has been studied using CT as reference.

Methods

Ten subjects were included in the study, approved by the local Ethics and Radiation Committees. Each subject, lying in supine position, with the arms stretched above the head, was imaged with both modalities within three hours. A CT scanner (HiSpeed Advantage, General Electric, USA) was used to acquire 28 axial images, positioned in accordance with a protocol for multicompartment body composition[1] (fig 1b). Scan parameters were 120kVp, between 40 and 240mAs depending on body part and body size, 480mm FOV, 5mm slice thickness, matrix 256, resulting in an average effective dose per examination less than 1 mSv. The image analysis was performed using a in-house created software providing automatic area measurements. Pixels with Hounsfield values -191 and above were considered to outline the body contour, including skin. A T1 weighted FFE MRI sequence was used on a 1.5T clinical MRI scanner (Gyroscan NT, Philips Medical Systems, The Netherlands, release 9) to acquire the whole-body volumes using the parameters: repetition time (TR) 155ms, echo time (TE) 2.3ms, FOV 530mm, slice thickness 8mm, and, matrix 256. Continuous slices were acquired over the whole body using breath holds over the thoracic and the abdominal regions. A small subset of all MRI data was used for the comparison. For each CT image, a corresponding MR image was visually selected based on congruence in anatomical structures. The MR image quality did not allow accurate inclusion of the skin. Hence, the images were analysed using a threshold for automatic delineation of the outermost subcutaneous adipose tissue (SAT) area. The threshold was determined using a method proposed by Otsu[2] and was applied on the histogram of the border region, masked from the body using a morphological algorithm. In areas with thin or missing circumferential adipose tissue manual intervention was needed. Due to the out of phase effect in the interface between SAT and skin the real border of SAT is represented by an intensity valley. The delineation line was approximately moved into the valley by moving the delineation line one pixel outwards. Linear regression and two-sided paired t-test were used. P-values of less than 0.01 were considered significant.

Results

The mean area differences (MRI minus CT) and correlations are shown for the slice-wise analysis in figure 1a. The slices 1, 2, 12, and, 28 differed significantly between MRI and CT. Correlating the subject-wise summed slice areas for MRI and CT gave the linear relationship MRI = 0.938·CT + 919, R= 0.998 (fig 2).

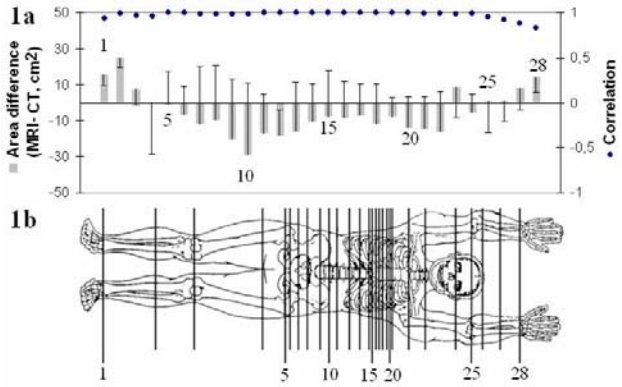

Fig. 1a. Slice-wise area correlations and differences (MRI minus CT, cm^2) illustrated by mean values and one-sided standard deviation bars.

Fig. 1b. Illustration of the 28 slice positions.

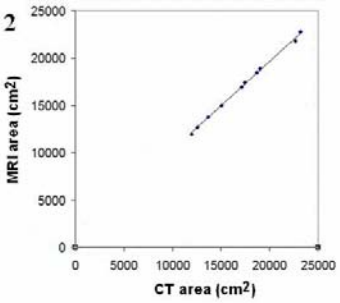

Fig. 2. Scatter plot of the summed slice areas for the ten subjects, given in cm^2.

Discussion

The areas measured using MRI and CT correlate strongly. The slice-wise mean area differences (fig 1a) indicate an underestimation of the measured MRI areas for positions with large slice areas (positions 4-26) and an overestimation where the measured slice areas are small (positions 1-3, 27-28). The slice-wise correlations (fig 1a) were lower in slices with low slice areas measured. The differences measured were likely caused by errors in slice positions, errors due to soft tissue motion, non-identical positioning of the subjects and the inclusion of skin in the CT analysis and exclusion of skin in the MRI analysis. The total area difference between MRI and CT is equal to the area of 0.9mm thick layer added to all MRI regions, which is likely explained my the absence of skin in the MRI analysis.

References

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