WHOLE-BODY MRI FOR ANALYSIS OF BODY COMPOSITION

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ABSTRACT

The large variability seen in human body composition and the importance of regional adiposity makes imaging the most powerful tool in body composition assessment. MRI is often the method of choice since it has no known long-term side effects, allows large coverage, repeated acquisition, and studies of children and adolescents. Various techniques are used to acquire and analyse whole-body MR data for assessment of body composition. Dixon imaging techniques can be used to derive chemical shift separated water and fat images from multi echo image acquisitions. The standard procedure for whole body investigations uses imaging of multiple sub volumes, using a step-wise stationary table, that might be stitched together in the post processing. The latest development in the field of whole-body MRI (e.g. by acceleration of data acquisition and by the introduction of a moving-table-scanning) has lead to reduced imaging times and increased patient comfort. Our research group has created and validated a fully automated algorithm for segmentation of intra-abdominal/visceral adipose tissue from whole-body water and fat images, rapidly acquired using moving-table-scanning. Today whole-body MRI plays an important role in studies of body composition. Not only can it be used to assess reduction but also the redistribution of adipose tissue, which will also likely be an important feature of future interventional studies.

Index Terms — Magnetic Resonance Imaging, Whole-Body, Body Composition, Visceral Adipose Tissue, Automated Image Processing

Analysis of body composition of human beings increases the understanding of the complex relationship between the composition of the human body and metabolism in normal as well as in pathological conditions. The correlation between central obesity, especially the amount of intra abdominal or visceral adipose tissue (VAT), and type II diabetes mellitus is a strong factor bringing attention to this field.

The large variability seen in human body composition and the importance of regional adiposity makes imaging the most powerful tool in body composition assessment. The use of computed tomography exposes the subject to radiation. Radiation limits coverage, longitudinal studies, and studies of children and adolescents. MRI is often the method of choice since it has no known long-term side effects, allows large coverage, repeated acquisition, and studies of children and adolescents.

Whole-body MRI analysis is motivated by the increased ability for accurate phenotype determinations. Age and ethnicity are for example known to impact body composition and studies including these factors likely gain from more extensive analysis.

The use of whole-body MRI is limited by the size of the bore. This might be a significant problem when obese subjects are investigated. The hardware vendors are therefore focusing on this problem when designing new scanner models. The use of large field of view imaging generally also results in reduced image quality in the image periphery. The relatively high cost of MRI, compared to more simple techniques for body composition assessment is also a limiting factor.

Denser data sampling increases accuracy and reproducibility and should therefore also allow better assessment of regional and longitudinal changes, e.g. after intervention. Larger coverage, denser sampling, and repeated acquisitions demand automation of the data processing. Automation is complicated as MRI intensity levels are given in arbitrary units (AU) and as images are often affected by intensity inhomogeneities.

Various techniques are used to acquire and analyse whole-body MR data for assessment of body composition [1-4]. Acquisition techniques use contiguous or sparse (using inter slice gaps) data sampling. Contiguous data sampling gives more information but increases the time needed for analysis, especially when manual interaction is needed. An advantage of contiguous data sampling is that it allows use of 3D information in the analysis automation. Sparse data sampling allow reduction of the acquisition and data processing times.

Dixon imaging techniques can be used to derive chemical shift separated water and fat images from multi echo image acquisitions [5-6]. These techniques allow quantification of fat content and form an alternative to fat suppression.
Whole-body Dixon imaging is of interest in studies of obesity and the metabolic syndrome, and seemingly also in oncology [7].

Conventional T1-weighted images are commonly manually or automatically thresholded based on image intensity. Some applications also compensate for image intensity inhomogeneities. Automated separation of visceral and subcutaneous adipose tissue is demanding. Hence, the most commonly used method is manual delineation. However, algorithms for automated segmentation of subcutaneous and visceral adipose tissue from abdominal data have been reported [8-10]. A standardized topography that interpolates results from analysis of axial slices over the whole-body region based on anatomical positions has been proposed [2].

The standard procedure for whole body investigations uses imaging of multiple sub volumes, using a step-wise stationary table, that might be stitched together in the post processing. The latest development in the field of whole-body MRI (e.g. by acceleration of data acquisition and by the introduction of a moving-table-scanning [11]) has lead to reduced imaging times and increased patient comfort, and therefore also increased acceptance.

Our research group has access to a scanner with continuously moving bed imaging (COMBI) which we have used for rapid collection of whole-body water and fat image data for analysis of body composition [4], Figure 1. One advantage of the use of water and fat images is that they are relatively robust to the large field of views needed in these studies. With the use of ratios between the fat and water signals (e.g. by use of fat fraction images) a very homogenous signal is achieved over the whole-body volume. Our research group has created and validated a fully automated algorithm for segmentation of VAT from these datasets and we have used this technique in a study of obese subjects to assess changes induced by low calorie diet and gastric bypass surgery.

Today whole-body MRI plays an important role in studies of body composition. Not only can it be used to assess reduction but also the redistribution of adipose tissue, which will also likely be an important feature of future interventional studies.

REFERENCES