Introduction: Brown adipose tissue (BAT) is a thermogenic tissue known to be present in human infants. BAT is believed to diminish with age and be essentially undetectable in adults [1, 2]. However, recent 18F-fluorodeoxyglucose (18F-FDG) positron emission tomography (PET) studies suggest that small but metabolically significant amounts of BAT persist into adulthood. These studies further suggest an inverse relationship between BAT and obesity, although it remains unclear whether reduced BAT amount and/or activity promotes or results from obesity [3]. Additional studies using CT have imaged and confirmed the presence of BAT in adult humans [4, 5], indicating that imaging human BAT is possible. Therefore, reliable identification and spatial mapping methods that can distinguish BAT from white adipose tissue (WAT) would provide investigators with a powerful tool with which to study BAT’s influence on body metabolism and composition. Animal studies indicate that BAT has a fat/water fraction greater than lean tissue but lower than WAT [6]. Consequently, we hypothesize that BAT may be visualized and quantified in humans using MRI methods such as fat-water MRI (FWMRI). We therefore examined adipose tissue, in locations suggested by PET studies to harbor BAT, in two 40-year-old adult males to investigate if it is brown or white adipose tissue.

Methods: MRI Acquisition: A whole-body FWMRI scan was performed at thermoneutral conditions on two volunteers which revealed a section of tissue with characteristics (location and size) associated with BAT. Subject A is a weight lifter with a high body mass index, and subject B is lean and athletically fit. All scans were performed on a Philips 3T MRI system (Philips Healthcare, Best, The Netherlands) after obtaining written informed consent, using the quadrature body coil for both excitation and reception. The whole-body FWMRI was acquired using a multi-slice, multi-gradient-echo (mFFE) acquisition with twelve contiguous 8mm slices per stack. TR=75ms, TE1/TE2/TE3=1.34/2.87/4.40(ms), flip angle=20°, water fat shift=0.325, readout sampling bandwidth (BW)=1336Hz/pixel, axial in-plane field of view = 500mm x 390mm, ACQ voxel size = 2mm x 2mm x 8mm.

Data Analysis: Fat and water signal components are found by least squares fitting [5] after the true solution is identified by imposing 3D spatial smoothness in a region-growing scheme that allows low confidence regions to be solved after high confidence regions are classified. The reconstruction of the fat and water images was performed using a technique developed by Berglund et al. [7]. Using MATLAB scripts developed in-house for analysis, the whole-body FWMRI scan was used to localize the deposits of interest in the supraclavicular region.

Results and Discussion: The suspected BAT deposits are indicated by the white arrows on the coronal images of the two subjects in Figure 1a and b. These figures show the tissue of interest, in the anterior supraclavicular region. From earlier ex vivo animal research the fat signal fraction of BAT is expected to range from 40-80% [6], and as can be seen in Figures 1a and b, the tissues of interest fall within this range. Because of the functional and morphological differences between WAT and BAT, it should be possible to differentiate the two tissues using MRI. BAT cells contain a higher proportion of lipid signal than lean tissue. For this reason it is possible to use the fat signal fraction map to differentiate between BAT and WAT depots. Partial volume effects are a concern, and until the tissue is confirmed to be BAT, it is possible that partial volume effects could explain the lower FSF values. However, the tissue volumes of interest are large enough that the lower FSF values are not completely explained by boundary effects. Future work will involve obtaining higher resolution scans to reduce partial volume effects.

Conclusion: This preliminary work suggests MRI can be used to detect and quantify the presence of brown adipose tissue in adult humans. Unlike PET, which is the current gold standard of imaging BAT, the ability to image BAT using MRI would avoid radiation exposure. Additionally, MRI-based studies of BAT involving pediatric subjects as well as longitudinal studies would not be hampered by the concern for radiation exposure. Future work will involve validation with PET-CT and histology, to confirm the MRI findings. Because BAT is more often observed in leaner individuals and is inversely correlated with other metabolic syndrome indices, it is likely that increasing BAT mass and/or activity may counteract obesity. Therefore, the ability to non-invasively detect and quantify BAT could lead to a better understanding of the role of BAT in obesity and metabolism.