VARIATIONS IN T2* AS A POTENTIAL INDICATOR OF HUMAN BROWN ADIPOSE TISSUE

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INTRODUCTION - Findings of brown adipose tissue (BAT) in humans by PET/CT have reinvigorated interest in the tissue's physiological role **[1, 2]**. In contrast to white adipose tissue (WAT), which functions to store fat, BAT metabolizes fat in response to diet and non-shivering thermogenesis. BAT is also highly vascularized and rich in mitochondria organelles. While PET/CT imaging of BAT has limitations, it remains the current gold-standard modality for BAT detection. First, PET/CT is restricted to oncology patients and not applicable to the general population, due to radiation and ethical restrictions. Second, it can only detect metabolically active BAT that uptakes the injected radionuclide tracer. Recently, studies have demonstrated BAT MRI in rodents by exploiting intrinsic cellular differences between BAT and WAT **[3-5]**. The purpose of this preliminary work was to investigate whether increased iron content in BAT (from blood hemoglobin and mitochondria) leads to detectable differences in T2* between BAT and WAT. Specifically, we hypothesize that BAT T2* will be *shorter* than WAT T2* and undertake the present study in humans.

METHODS - ***Patients*** – Two oncology patients undergoing PET/CT examinations at our institution for medical care were recruited and consented for subsequent MRI studies. One patient (Subject A), a 26-year-old Caucasian male, exhibited *positive* signs of bilateral interscapular BAT radiotracer uptake on his PET/CT images (**BAT+**). This is the most prominent BAT depot known in humans. The other patient (Subject B), a 49-year-old Caucasian female, was BAT *negative* on her PET/CT images and served as the control (**BAT-**). MRI scans of these patients were performed on a 3T system (Excite HD, 15M4, GE Healthcare). A 3D SPGR sequence based on the chemical-shift water-fat decomposition technique IDEAL with T2* estimation **[6]** was utilized with the following parameters: TR=9.5ms, first TE=1.59ms, ΔTE=0.79ms, 6-peak fat model, 6 echoes, flyback (unipolar) readout, BW=±125kHz, α=10°, two-fold parallel imaging acceleration, 1mm isotropic in-plane resolution, and 1.1mm slices. Data were acquired in both axial and coronal planes. ***Volunteers*** – Four healthy volunteers (3 males, 1 female) between the ages of 26 and 32 were additionally recruited for MRI studies. For the volunteers, MRI was performed on a 3T system (Achieva, R3.2, Philips Healthcare). Similarly, a 3D axial SPGR sequence based on a multi-echo chemical-shift water-fat decomposition algorithm **[7]** was utilized. Imaging parameters were: TR=9.4ms, first TE=1.48ms, ΔTE=1.2ms, 7-peak fat model, 6 echoes, non-flyback (bipolar) readout, BW=±190kHz, α=3°, two-fold parallel imaging acceleration, 1mm isotropic in-plane resolution, and 2mm slices with 1mm overlap. For all MRIs, co-registered water-only (W), fat-only (F), fat-signal fraction ($F/[F+W]$, 0-100%), and T2* maps were reconstructed. PET/CTs were not approved on volunteers.

RESULTS - Figs 1-2 illustrate results from the patients. Noticeable differences in fat-signal fraction and T2* values can be observed between interscapular BAT and subcutaneous WAT in Subject A (BAT+), whilst such differences are diminished and not visually evident in Subject B (BAT-). Fig. 3 summarizes results from the volunteers. Note in each case that although the interscapular fat depot appears rather homogeneous in fat-signal fraction, the associated T2* map exhibits a noticeable heterogenous distribution of low and high values. Note the second subject, who is lean, has the lowest BAT fat-signal fraction and T2*, and is devoid of subcutaneous WAT. Note also the subcutaneous WAT in the other three, particularly the fourth subject, which exhibits higher T2* than their corresponding BAT depots.

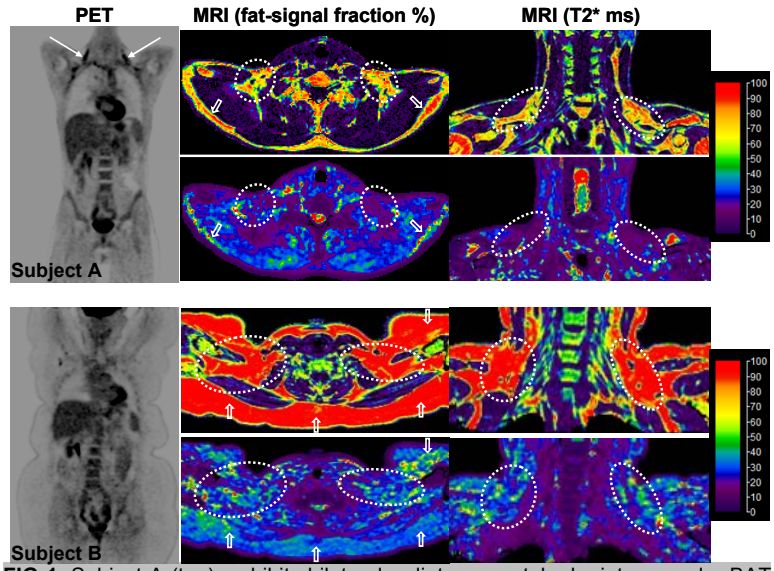

FIG 1. Subject A (top), exhibits bilateral radiotracer uptake by interscapular BAT (**solid arrows**) from PET, in contrast to Subject B (bottom). Axial and coronal fat fraction and T2* color maps are shown using the *same* 0-100 scale, in units of (%) in the former and (ms) in the latter. Interscapular fat pads are denoted in all images by **dotted circles**, while subcutaneous WAT are highlighted by **open arrows**. In Subject A (BAT+), the interscapular fat pads exhibit lower fat fractions and T2* values than WAT. In Subject B (BAT-), the differentiation is less evident.

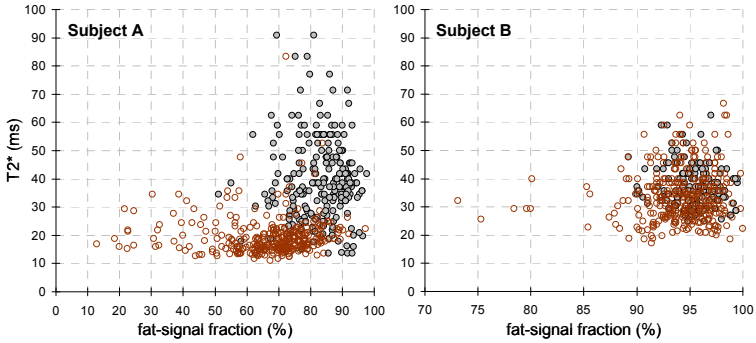

FIG 2. Scatterplots of fat-signal fraction (%) vs. T2* (ms) from regions-of-interest drawn about the interscapular fat pad (**brown circles**) and subcutaneous WAT (**gray circles**). Note in Subject A (BAT+) that the interscapular BAT fat pad clearly exhibits lower fat-signal fraction and T2* metrics than subcutaneous WAT. In contrast in Subject B (BAT-) the data points overlap significantly. Note compressed horizontal fat-signal fraction scale from 70-100% in Subject B.

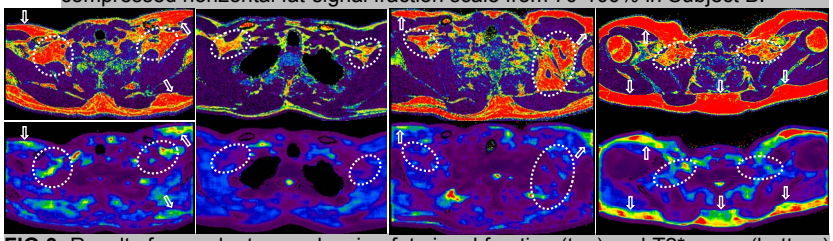

FIG 3. Results from volunteers, showing fat-signal fraction (top) and T2* maps (bottom) from four subjects. Notations and color scale same as FIG. 1.

CONCLUSION - This work has demonstrated variations in T2* in human adipose tissue. We speculate that this is potentially due to the presence of BAT and more specifically the presence of iron from blood perfusion and the tissue's abundant mitochondria. Thus, T2* may serve as an adjunct in the identification of BAT *in vivo*.

REFERENCES - **[1]** Cannon B. Physiol Rev 2004:84:277-359. **[2]** Nedergaard J. Cell Metab 2010:11:268-272. **[3]** Hu H. JMRI 2011:34:468-473. **[4]** Hamilton G. JMRI 2011:34:468-473. **[5]** Branca R. MRM 2011:65:313-319. **[6]** Yu H. JMRI 2007:26:1153-1161. **[7]** Eggers H. MRM 2011:65:96-107.