Effect of High Fat/High Fructose Diet on Canine Model Using Quantitative Fat Water MRI

Myriam Diaz Martinez[1,2], Aliya Diaz Gifford[2,3], Philip E Williams[4], Alan D Diaz Cherrington[4], Malcolm J Avisom[5], and E Brian Welch[3,6]

[1]Department of Radiology and Radiological Sciences, Vanderbilt University, School of Medicine, Nashville, TN, United States, [2]Chemical and Physical Biology Program, Vanderbilt University Medical Center, Nashville, TN, United States, [3]Vanderbilt University Institute of Imaging Science, Vanderbilt University Medical Center, Nashville, TN, United States, [4]Department of Molecular Physiology and Biophysics, Vanderbilt University, Nashville, TN, United States, [5]Department of Pharmacology, Vanderbilt University, School of Medicine, Nashville, TN, United States, [6]Department of Radiology and Radiological Sciences, Vanderbilt University, School of Medicine, Nasville, TN, United States

The chronic consumption of a high fructose/high fat diet can lead to obesity which is a chronic, life threatening condition that increases the risks for other comorbidities such as heart disease, high blood pressure, and the onset and progression of type 2 Diabetes Mellitus (T2DM)[1-4]. Therefore, the ability to quantitatively track changes in adipose tissue deposition within the whole body of a well-characterized canine animal model is crucial to improve the understanding of (1) AT distribution in tissues and organs and (2) its correlation with the development of obesity and associated conditions such as insulin resistance[1-3,5].

Purpose: The purpose of this study was to detect organ-specific changes in fat-water signal fraction over the course of high fat/high fructose diet consumption by exposing a canine animal model to the diet. Measurements were acquired using the quantitative method of fat-water MRI (FWMRI), with interleaved multiecho pulse sequence, which is a new imaging modality for the research areas of obesity and metabolic diseases.

Methods: Three adult male dogs consumed a high fat/high fructose diet with a total energy of 1900kcal/day for ~6 weeks as described previously[1]. Canines were scanned under anesthesia (5% isoflurane/oxygen) with the Philips Achieva 3T (Philips Healthcare, Best, The Netherlands) at two time points: (i) before starting the high fat/high fructose diet (week 0) and (ii) after 6 weeks on the diet (either on days 39 or 42). MRI sequences were performed using the X-tend table with the torso XL coil and FWMRI was acquired using a multi-stack, multi-slice, multi-gradient echo (mFFE) acquisition with 7 stacks, 30 contiguous slices per stack. TR = 84 ms, 8 echoes (4 echoes×2 interleaves) TE1/effective ΔTE=1.05/0.783 ms, flip angle=12, water fat shift = 0.323 pixels, readout sampling bandwidth=1346.1Hz/pixel, axial in-plane FOV=400mm×280mm, acquired voxel size=2 mm×2 mm×5 mm, with SENSE factor=3, and acquisition time=27 s/stack.

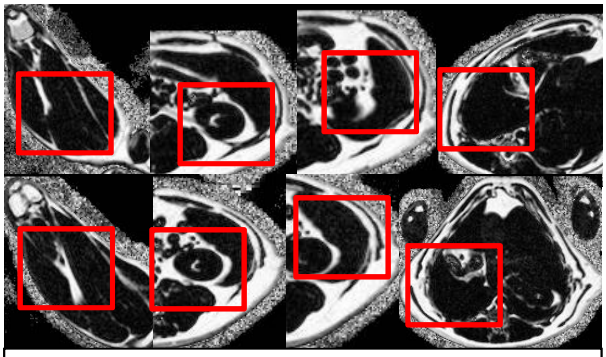

Figure 1. Selected fat signal fraction images of K901 from left to right: Limb muscle, kidney, spleen and liver of week 0 (top) and week 6 (bottom); high intensity indicates high FSF and low intensity indicates low FSF.

Results: Table 1 shows the lower and upper bound of 95% confidence intervals of fat signal fraction (FSF) of two data points: at week 0 and week 6 for subcutaneous and visceral adipose tissue depots, as well as, kidney, liver, spleen and limb muscle of all three dogs. The liver and subcutaneous FSF showed a significant increase, while the rest of the selected tissues' FSF did not change significantly. Figure 1 shows examples of the examined anatomical regions in which high FSF is represented by high intensity and low FSF is represented by low intensities.

Table 1. 95% Confidence Intervals of FSF of selected organs and tissues of all three dogs. Values in red showed significant differences between week 0 and week 6 of the high fat/high fructose diet.

		95% Confidence Intervals, Lower and Upper Bounds of Fat Signal Fraction											
		Subcutaneous Fat		Visceral Fat		Kidney		Liver		Spleen		Limb Muscle	
K901	Wk 0	94.3%	95.5%	94.3%	95.5%	5.1%	5.9%	4.3%	4.6%	5.3%	5.8%	6.7%	7.4%
	Wk 6	95.7%	96.4%	94.7%	95.3%	5.4%	6.4%	6.6%	6.9%	7.8%	8.4%	6.3%	6.8%
K902	Wk 0	79.1%	81.2%	94.0%	94.9%	4.6%	5.2%	4.9%	5.2%	5.7%	6.1%	7.0%	7.5%
	Wk6	89.9%	91.0%	95.3%	95.7%	4.9%	5.1%	5.8%	6.2%	5.4%	5.8%	8.3%	9.4%
K903	Wk 0	93.0%	93.4%	96.1%	97.1%	4.8%	5.6%	3.1%	3.3%	9.2%	10.1%	5.0%	5.3%
	Wk 6	94.4%	94.8%	94.3%	94.9%	5.1%	6.0%	4.7%	5.0%	6.0%	6.4%	5.9%	6.5%

Discussion: Our results confirm the quantitative utility of FWMRI for non-invasive longitudinal studies to measure tissue and organ fat signal fraction in a well-established, metabolically well-characterized, and clinically relevant canine model. Results presented here show that a high fat and high fructose diet can increase the fat signal fraction in liver and in subcutaneous tissue, which is consistent with the early development and onset of T2DM.

References: [1] Coate, K, et al; AJEM 887(299); 2010 [2] Gifford, et al; JMRI 0(0);2013. [3] Twells LK.et al.; PHM 15(29);2012. [4] Bornert P, et al;JMRI 25(660);2007 [5] Kullberg J, et al;30(185);2009.