

# Quantification of Myocellular Lipids via $^1\text{H}$ -MR Spectroscopy in Elderly Women: Effect of Adiposity and Physical Activity

D. D. Chen<sup>1</sup>, D. Hernando<sup>2</sup>, C. L. Johnson<sup>1</sup>, A. A. Gharibans<sup>1</sup>, D. D. Guest<sup>3</sup>, C. Ward<sup>4</sup>, B. Das<sup>3</sup>, E. M. Evans<sup>4</sup>, and J. G. Georgiadis<sup>1,5</sup>

<sup>1</sup>Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, United States, <sup>2</sup>Department of Radiology, University of Wisconsin, Madison, WI, United States, <sup>3</sup>Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL, United States, <sup>4</sup>Department of Kinesiology, University of Georgia, Athens, GA, United States, <sup>5</sup>Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, Urbana, IL, United States

## Introduction

The “fit-or-fat” debate is of high clinical importance in the pursuit of interventions to ameliorate disability related to disordered body composition in the elderly. The absolute lipid content of skeletal muscle, particularly the concentration of intramyocellular lipids, is known to change with muscle function and health state and has been proposed as a indicator of muscle and metabolic disease or dysfunction [1,2], such as that associated with type 2 diabetes [2-4]. Proton magnetic resonance spectroscopy ( $^1\text{H}$ -MRS) has been successfully used to quantify the lipid content of skeletal muscle [1-5], which is commonly divided into two compartments: intramyocellular lipids (IMCL) and extramyocellular lipids (EMCL) [5]. While EMCL is relatively metabolically inert, IMCL can be utilized by the mitochondria making it the preferred form of lipid storage in a healthy muscle. By calculating the concentrations of IMCL and EMCL using the spectra obtained from  $^1\text{H}$ -MRS, we aim to assess the differences in muscular lipid storage between elderly women in three distinct fitness levels: obese, lean/sedentary, and lean/active.

## Materials and Methods

**Subjects:** A total of forty-one elderly women (age $\geq$ 59) comprising three groups: obese (O), lean/sedentary (LS), and lean/active (LA) were examined in this study. Women with a body mass index (BMI) greater than 28 were assigned to group O (n=24). Women with a BMI between 20 and 24.9 were assigned into groups LS (n=8) and LA (n=9) based on their daily activity level as determined by a pedometer.

**In vivo measurements:** All data was collected on a Siemens Magnetom Trio 3T whole-body scanner (Siemens AG Medical Solutions, Erlangen, Germany) with the subjects oriented in a feet-first supine position. Spectra were taken using a combination of an eight-channel spine coil and a flexible body matrix surface coil centered over the midpoint of the left thigh.  $^1\text{H}$ -MRS was performed in a single voxel (15x15x10mm<sup>3</sup>) located in the left vastus medialis adjacent to the femur (Fig. 1) using a CHESS sequence with TR/TE = 2000/30ms and N<sub>acq</sub> = 8. Two spectra were obtained without water suppression and thirteen were acquired with water suppression for normalization and averaging.

**Quantification of Lipid Concentration:** Similarly acquired spectra were combined, and the water and lipid peaks were fitted using Lorentzian functions with Gaussian priors (Fig. 2). In the non-water-suppressed spectra, areas were calculated for the water and lipid components and the total area approximated as the sum of these two areas. Total lipid concentration ([LPD]) was calculated as the area of the lipid component divided by the sum of the water and lipid component areas. In the water suppressed data, six peaks were fitted for determination of the total area, but only two were assigned to lipids: IMCL at 1.4 ppm and EMCL at 1.6 ppm. The IMCL fraction was defined as the IMCL component area divided by the sum of the IMCL and EMCL component areas and is a measure of lipid distribution. This was then multiplied with the total lipid concentration to calculate the IMCL concentration ([IMCL]). The EMCL concentration ([EMCL]) was then calculated as the difference between [LPD] and [IMCL].

**Statistical Analysis:** Student’s t-test was performed for each of the four calculated parameters in Table 1 using unequal variances, a one-tailed distribution, and the null hypotheses:  $\mu_O - \mu_{LS} \leq 0$ ,  $\mu_O - \mu_{LA} \leq 0$ , and  $\mu_{LS} - \mu_{LA} \leq 0$ .

## Results and Discussion

**Fitness Levels:** No significant differences were found in lipid content or distribution between groups O and LS. While the absolute concentrations of lipids were found to be greater in group O than in group LA ([LPD] and [EMCL], p<0.005; [IMCL], p<0.1), the IMCL fraction was greater in group LA than in group O (p<0.1). The same results were found when comparing group LS to group O; however, [IMCL] was not found to be significantly different between the two lean groups. These results are consistent with prior measurements in calf muscles [6].

**Lipid Storage:** Our findings are largely consistent with previous work in that obese subjects typically have higher concentrations of lipids within the skeletal muscle structure than lean subjects. However, this is dependent on whether the subject is active or sedentary. We found that the majority of the lipid signal comes from the EMCL and the results of the statistical analyses between groups were the same for [LPD] and [EMCL]. Due to the relatively lower contribution of IMCL to the total lipid signal, variations in [IMCL] do not necessarily reflect the comparisons for [LPD]. In fact, IMCL fraction is higher in the more active lean subjects, despite having a lower concentration of lipids present in the muscle. This difference in lipid storage is consistent with the current understanding of lipid metabolism [3], as IMCL can be utilized readily by the mitochondria, unlike the EMCL. A comparison of [LPD] and IMCL fraction is sufficient to identify the muscles of fitter subjects.

## Conclusion

Single-voxel  $^1\text{H}$ -MR spectroscopy was used to quantify the distribution of muscle associated lipids in a cross-sectional study involving forty-one elderly females grouped in terms of adiposity and physical activity. Using EMCL and IMCL concentration and IMCL fraction in a single voxel of the vastus lateralis muscle as a parameter, the difference between lean/sedentary and obese individuals is statistically insignificant, while lean/active individuals have a lower concentration of lipids (p<0.005) with a higher percentage stored as IMCL (p<0.1) than the other groups.

**References:** [1] Boesch C et al., *NMR Biomed.* 19: 968–988, 2006; [2] Goodpaster BH et al., *Am J Clin Nutr* 79: 748–754, 2004; [3] Goodpaster BH, *J Clin Endocrinol Metab* 86: 5755–5761, 2001; [4] Sinha R et al., *Diabetes* 51: 1022–1027, 2002; [5] Schick F et al., *Magn Reson Med* 29: 158–167, 1993. [6] Hwang J-H et al., *J Appl Physiol* 90: 1267–1274, 2001.

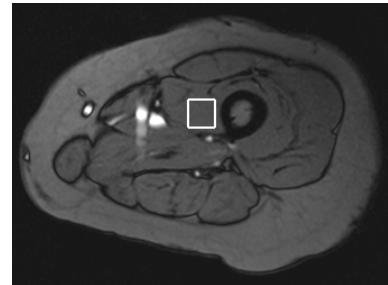


Figure 1. Placement of voxel for spectroscopy in vastus medialis.

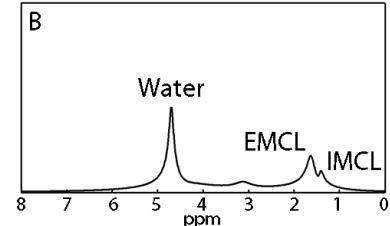
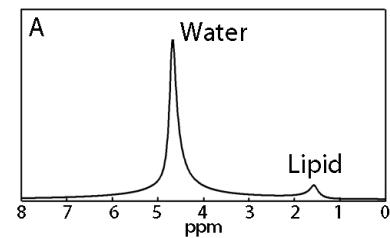


Figure 2. Peaks of fitted (A) non-water-suppressed and (B) water-suppressed spectra.

Table 1. Computed mean and standard deviations

	Obese (O)	Lean: sedentary (LS) / active (LA)
	$\mu$ ± $\sigma$	$\mu$ ± $\sigma$
[LPD] (%)	6.306 ± 2.022	5.390 ± 1.821
[IMCL] (%)	0.747 ± 0.467	0.470 ± 0.540
[EMCL] (%)	5.559 ± 2.160	4.919 ± 1.961
IMCL fraction	0.140 ± 0.108	0.098 ± 0.123
	0.207 ± 0.126	