Functional Imaging Including MRS, BOLD, Dynamic Imaging

Dr. Michael D. Noseworthy, PhD PEng
Co-Director, McMaster School of Biomedical Engineering,
Associate Professor, Department of Electrical and Computer Engineering,
McMaster University.
1280 Main St. West, Hamilton, Ontario. Canada L8S 4K1
http://www.ece.mcmaster.ca/~mikenose/web/HOME.html

Functional imaging of skeletal muscle can be performed using a number of different in vivo magnetic resonance approaches such as blood oxygen level dependent (BOLD) imaging, magnetic resonance spectroscopy (MRS) and dynamic imaging using contrast agents (dynamic contrast enhanced MRI, dceMRI). Musculoskeletal dynamic imaging is also a term given to the repeated imaging of joints at various stages/angles of motion and subsequent viewing as a movie.

BOLD muscle imaging is done following some form of physiological challenge such as reactive hyperemia, breathing hyperoxia/hypercapnia, voluntary exercise or electrical stimulation, etc. The BOLD signal represents change in tissue oxygenation which is reflective of a combination of effects from metabolism, blood flow and blood volume changes. BOLD measurements can be combined with blood flow measures, derived from arterial spin labelling, to better understand the relative contributions of each physiological factor to the BOLD signal changes seen with the specific physiological challenge.

MRS, or *in vivo* nuclear magnetic resonance (NMR) permits understanding of metabolic change within muscle tissues. This can be done with or without the challenges described above. The most frequent approaches include ^{1}H-MRS and ^{31}P MRS, but occasionally other nuclei are probed (e.g. ^{13}C). Non-^{1}H approaches are more difficult in that localization is more challenging and a great deal of extra hardware is required (RF coil tuned to the nucleus of interest and also a broadband RF amplifier and T/R switch capable of working with non-proton nuclei).

Dynamic Imaging with contrast agents (e.g. gadolinium chelates) is useful for understanding muscle microvascular perfusion and permeability. This approach can be used to differentiate slow and fast twitch dominant muscles as the slow twitch has greater microvascular density (e.g. soleus vs. gastrocnemius, where the latter is fast and former slow twitch). Most often dceMRI is used for better understanding of a tumour microenvironment.

The details presented in this talk have been summarized in a number of review papers and basic science papers (below). If the interested reader cannot access any of these papers online I would be delighted to send them via email.

1. Kumbhare DA, Elzibak AH, Akbari A, Noseworthy MD. (2014). Advanced skeletal muscle MR imaging approaches in the assessment of muscular dystrophies. Int. J. Phys. Med. & Rehab. 2:248. doi: 10.4172/2329-9096.1000248
2. Noseworthy MD, Davis AD, Elzibak AH. (2010) Advanced MR imaging techniques for skeletal muscle evaluation. Sem. Musculoskel. Radiol. 14:257-268.
3. Wells GD, Noseworthy MD, Hamilton J, Tein I. (2008) Skeletal muscle dysfunction in obesity: New ideas and concepts. Can J. Neurol. Sci. 35:31-40.
4. Wells GD, Wilkes D, Schneiderman JE, Rayner T, Elmi M, Selvadurai H, Dell S, Noseworthy MD, Ratjen F, Tein I, Coates AL. (2011) Skeletal muscle metabolism in cystic fibrosis and primary ciliary dyskinesia. Pediatric Res. 69:40-45.
5. Caterini JE, Elzibak AH, St. Michel EJ, McCrindle BW, Redington AN, Thompson S, Noseworthy MD, Wells GD. (2014) Characterizing blood oxygen level-dependent (BOLD) response following in-magnet quadriceps exercise. Magn Reson Mater Phy (MAGMA). Sep 24. [Epub ahead of print] PMID: 25248947