[31]P nuclear magnetic resonance spectroscopy in exercising muscle: Increasing sensitivity, resolution and combination with other modalities.
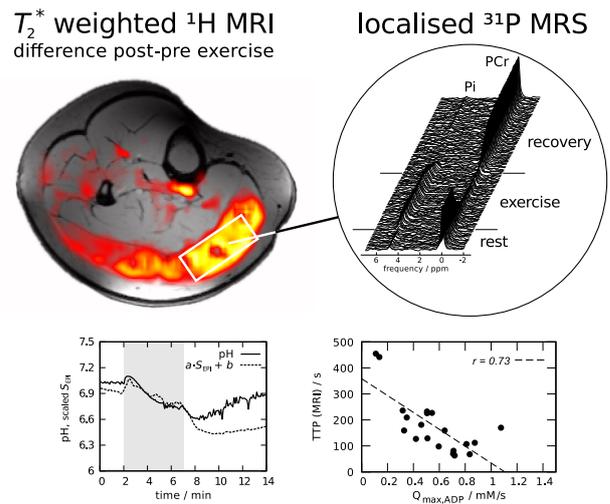
Nuclear magnetic resonance (NMR) is the basis for magnetic resonance imaging, a major clinical tool in radiology today. It allows the non-invasive acquisition of two- and three-dimensional image data from various organs with a large diversity of contrasts, that show anatomical and functional features without exposing the patient to ionising radiation.

Beyond these applications which mostly exploit the magnetisation of ^{1}H nuclei as source of the measured signal, biomedically relevant information can also be acquired using other NMR-sensitive nuclei, e.g. [13]C, [23]Na or [31]P. These are generally less abundant and have lower intrinsic sensitivity, but permit a wider view on the metabolism and the state of tissue under investigation. Phosphorus (^{31}P) NMR, and particularly ^{31}P MR spectroscopy can reveal quantitative information about phosphorylated high energy metabolites.

Interestingly, it is possible to acquire this information in dynamic experiments with a time resolution that is adequate to follow the depletion of phosphocreatine during muscle exercise and the subsequent replenishment of the PCr pool, reflecting the dynamics of (mostly oxidative) ATP resynthesis, along with information on intracellular pH from the same data set, which allows to measure, for example, maximum oxidative capacity of the tissue under investigation.

Since the first ^{31}P MRS experiments were performed on experimental machines, the introduction of clinical MR scanners with higher and higher magnetic field strength and improvements in radiofrequency coil design, both applicable also to non-[1]H-measurements, have lead to an increase of signal-to-noise ratio of data that can be acquired in vivo. Increased sensitivity can be invested into temporal and/or spatial resolution by employing advanced acquisition schemes.

T_2^* weighted ^{1}H MRI
difference post-pre exercise

localised ^{31}P MRS

Schmid AI, Meyerspeer M et al. NMR Biomed 2014;27(5):553

This presentation will give insight into the improvements that can be expected from various technological steps (localisation technique, dedicated multi-channel RF coils, and increased field strength) and the effect on metabolic parameters deduced from such ^{31}P measurements and their combination with concurrently acquired dynamic ^{1}H MRI of exercising muscle.