31P MRS of the biceps brachii muscle at 3T

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Introduction

Phosphorous (31P) MR allows for non-invasive monitoring of muscle bioenergetics and has been used in clinical research to assess metabolic changes in skeletal muscle with exercise, aging, and disease (Larsen, 2009. Conley, 2000. Argov, 2000.). Until now the muscle most commonly investigated has been the calf muscle, however there is interest in examining other muscle groups such as the quadriceps, tibialis and biceps brachii (Béliveau, 1991). The exercise device is one of the most critical components in the experiment. Typically, custom built devices are used. The adoption of 31P MRS in the clinic is hampered by the fact that a custom built device is needed for the measurements, and additional time and expertise is required for its set up on each measurement. The biceps brachii could be of interest as a model for monitoring of muscle bioenergetics, with a simple isometric exercise (i.e., holding a weight for ~ 2min.)

The aim of the present study was to investigate a simple method for performing 31P spectroscopy on the biceps brachii muscle, and to determine its potential as a model for future 31P investigations.

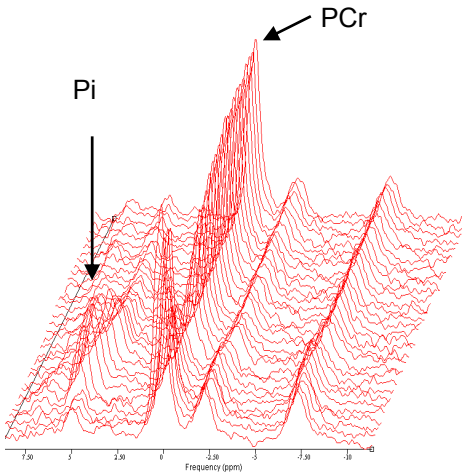

Fig 1. Stack plot of 31P spectra acquired at rest, during exercise and following exercise of biceps brachii muscle. Scan time of each spectrum = 15s.

Methods

MRS experiments were performed on a clinical Siemens 3T Tim Trio (Siemens Healthcare, Erlangen, Germany) with a custom-built 31P surface coil of 13cm diameter. After high-order shimming with the body coil, spectra of the biceps of three healthy volunteers were acquired using a pulse-acquire sequence (15s per spectrum, TR = 1.88s, 0.5ms dwell time, 1024 readout points). Volunteers performed isometric flexion of the elbow while holding weights in their hand for 2 minutes. Weighting was approximately equivalent to 8-10% of lean body mass (lbm), calculated using a height, weight and gender algorithm (Hume, 1966).

Results

Good quality 31P spectra (Fig 1) show the typical dynamics of the PCr and Pi, during and following exercise. It should be noted that the position of the bicep in the scanner is not a favorable one, since it is laterally located towards the edge of the scanner bore, where B_0 inhomogeneities are higher. On the other hand, despite the larger linewidth of the resonances, spectral quality is sufficient to quantify metabolites amplitudes at rest, during and following exercise (Fig 2). An example of the monoexponential fit of ADP recovery is shown on Fig 3. The fit gives a time constant of 29.4s.

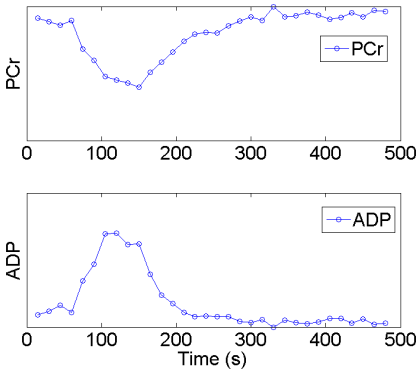

Fig 2. Time course of PCr and ADP at rest, during exercise and following exercise of biceps brachii muscle.

Discussion

There are several reasons to develop 31P MRS techniques in other muscle groups, such as the biceps method presented here. Firstly, there is variability in the composition of muscle fibre types between different muscles in healthy individuals, so that measurements from a single muscle do not necessarily represent all musculature (Jansson, 1977). Secondly, some muscle pathologies selectively affect certain muscle groups. For example, in COPD-associated muscle disease the quadriceps is selectively weakened, while the biceps is not (Man et al, 2009). Thirdly, the technique presented here is simple both in terms of setup *and* operation, and could be used in patients who are less able to perform complex tasks, such as children with inherited muscle disease, and eventually in a clinical diagnostic setting (e.g., Bendahan, 1998). We conclude that the biceps muscle is a good model for investigations of muscle bioenergetics. The current approach is simple and, as such, could be easily applied in clinical research settings.

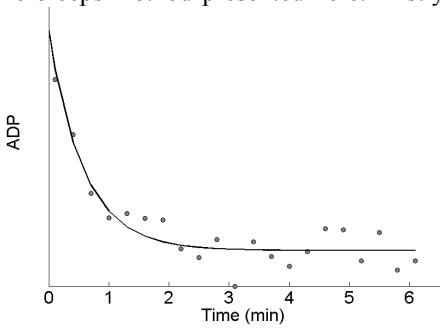

Fig 3. ADP recovery following exercise. The continuous line indicates the monoexponetial fit, Symbols indicate the experimental data points.

References. Argov Z, et al., *Neurologic clinics* 18, no. 1 (2000): 35–52. Conley KE, et al., *The Journal of Physiology* 526, no. 1 (2000): 203–210. Bendahan D, et al., *Anesthesiology* 88, no. 1 (1998): 96-107. Larsen RG, et al., *Journal of Applied Physiology* 107, no. 3 (6, 2009): 873-879. Jansson E, et al., *Acta Physiologica Scandinavica* 100, no. 3 (1977): 315-324. Béliveau L, et al., *Neurology* 41, no. 12 (1991): 1998-2001. Man W D-C et al., *Clinical Science* 117, no. 7 (8, 2009): 251-264. Hume R, *Journal of Clinical Pathology* 19, no. 4 (1966): 389-391.