PCr recovery rates of gastrocnemius medialis and soleus muscles at various exercise levels

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Introduction: The kinetics of PCr and Pi can be measured in vivo by time-resolved ^{31}P MR spectroscopy. Soleus (SOL) and gastrocnemius medialis (GM) muscles are both involved in plantar flexion exercise, but differences in anatomy and physiology make their individual quantification under varying workloads an interesting subject [1, 2]. The data presented was acquired in human SOL and GM using a single-shot localization technique (semi-LASER) which ensures extremely low contamination of the volume of interest, high SNR and therefore high achievable time-resolution.

Methods: Localized ^{31}P spectra [3] were acquired in SOL and GM during rest, plantar flexion exercise and recovery, using a custom multichannel ^{1}H/^{31}P coil array at 7T (voxel size ~ 36ml, T_E = 24ms, T_R = 6s, no averaging). 7 young healthy subjects exercised 3 minutes at 20%, 30% and 40% (for SOL additionally 50%) of maximum voluntary contraction force (MVC) each. pH was calculated from the chemical shift between PCr and Pi [4], PCr recovery rate, expressed as recovery time constant (τ), was fitted monoexponentially (see Fig. 1).

Results: In GM, τ increased with exercise intensity whereas in SOL this correlation was not observed, τ was constant and remarkably short [5], τ = 22±11s (see Fig. 2). PCr depletion in GM ranged from 16 to 96%, and was also correlated to τ (see Fig. 3). In SOL PCr depletion ranged from 6 to 53%, and again uncorrelated to τ. Interestingly, in three datapoints (of two subjects) with strong PCr depletion in SOL (50%) τ was still only 20s (see Fig. 3). pH in GM was correlated to PCr depletion as well (see Fig. 4). In SOL, PCr depletion levels were in a range where no pH correlation was expected.

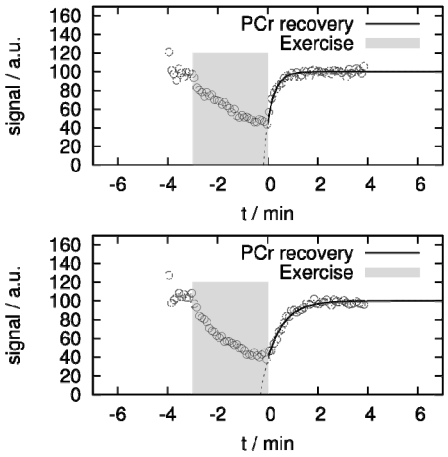

Figure 1: Fit of PCr recovery in SOL (top) and GM (bottom), at with comparable PCr

Conclusion: PCr recovery time τ was successfully quantified in GM and in SOL. Its correlation to other parameters (i.e. PCr depletion and exercise intensity) was different in GM and in SOL, not only during equal exercise levels of a subject, but also at comparable workload of individual muscles.

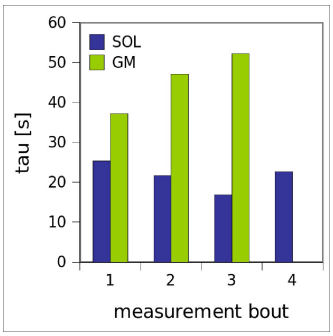

Figure 2: Average of τ in exercise bouts with 1) 20% 2) 30% 3) 40% and 4) 50% of MVC.

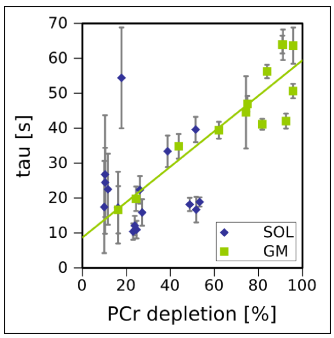

Figure 3: τ vs. PCr depletion. Green line is a linear fit of GM data.

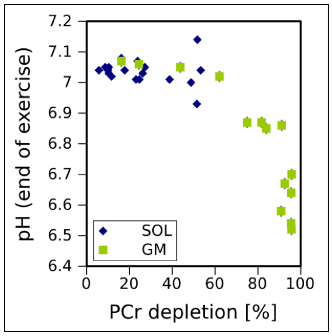

Figure 4: pH at end of exercise vs. PCr depletion.

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