Phosphocreatine line with changes in localised 31P MRS of exercising muscle at 7T

Martin Meyerspeer[1,2,3], Chrisine Nabuurs[3,4], Rolf Gruetter[3,4,5], Ewald Moser[1,2]
[1]MR Centre of Excellence, Medical University of Vienna, Austria; [2]Center for Biomedical Engineering and Physics, Medical University of Vienna, Austria; [3]LIFMET, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland; [4]Radiology, University of Geneva, Geneva, Switzerland; [5]Radiology, University of Lausanne, Lausanne, Switzerland

Introduction

Physical exercise of muscle tissue causes metabolite concentration changes, pH shift, alterations of water distribution, blood oxygenation level and -flow [1]. Physical exercise of muscle tissue causes metabolite concentration changes, pH shift, alterations of water distribution, blood oxygenation level and -flow [1]. Exercise has been shown to induce T_2 and T_2^* increase of tissue water, reflecting blood oxygenation. Our aim was to investigate changes in the linewidth in high energy phosphates solely originating from the intramyocellular compartment by temporally resolved and localised 31P-MRS after aerobic calf muscle exercise.

Methods Semi-Laser [2] localised ^{31}P-MRS of gastrocnemius muscle and pulse-acquire-MRS (10cm-surface coil) were performed alternatingley in three exercise bouts separated by >20min inactivity. PCr and Pi were quantified in AMARES from single acquitsitions, with T_R=6s.

Results The average (±SD, n=7 subjects) time course time courses of the PCr line width after a 5 min exercise is shown in Fig. 1. The intrinsic line width of PCr (T_2=217±14ms, [3]) is 4.7Hz. Resting PCr line width in localised spectra was 8.3±0.7Hz (mean±SD of first 10 data points), increased to 10.1±0.5Hz after exercise (3 points) and returned to base line of 8.1±0.3Hz (10 points, 5 min later). During plantar flexion exercise, PCr line width varied between 8 and 13Hz, due to motion. The distinct decrease of PCr line width during recovery in localised ^{31}P-MRS is not evident in unlocalised pulse-acquire experiments (Fig. 1). PCr line width is 24.9±0.2Hz in early recovery, and 24.1±0.2Hz after 5 min.

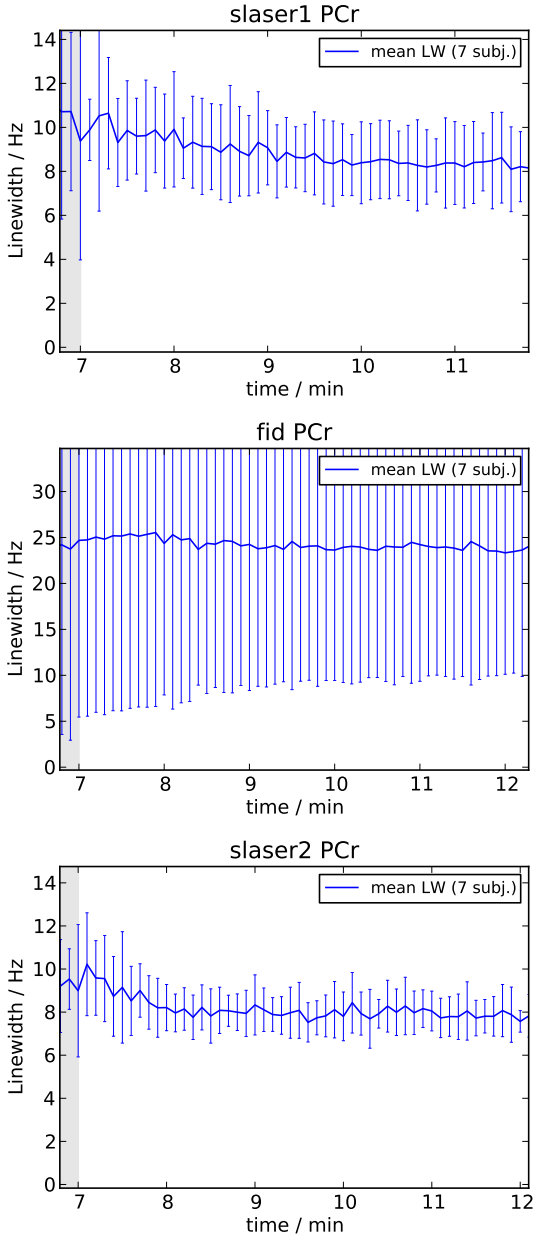

Fig. 1: Line width of PCr resonance measured in 7 subjects (mean±SD) during recovery from aerobic exercise. Three exercise bouts were performed subsequentially with/without/with localisation.

Despite equal exercise intensity, PCr depletion measured with a localising sequence (79±7%) was stronger than without localisation (53±10%). Also PCr recovery half times (34s vs. 42s) and pH changes were different (unlocalised: Pi peak splitting), indicating that signals in localised MRS represent only exercising muscle tissue, while non-localised signals contain additional contributions from less or non-exercising muscles.

Discussion and Conclusion While Pi line width is known to change due to pH [4], to our knowledge this is the first observation of an exercise induced line width increase of intra-myocellular PCr, which may be related to myoglobin deoxygenation. Motion as cause seems unlikely, as LW slowly decreases long after exercise. The effect is far less pronounced in unlocalised spectra which contain larger fractions of resting tissue.

Acknowledgements: We thank Claire Wary for stimulating discussions.
Fundings: FWF/J3031, CIBM/EPFL, Leenaards and Jeantet Foundations.

References

[1] Carlier PG [2011] Adv Exp Med Biol 915:341–346.

[2] Meyerspeer M, Scheenen T, Schmid AI, Mandl T, Unger E, Moser E [2011] Magn Reson Med 65:1207–1215.

[3] Bogner W, Chmelík M, Schmid AI, Moser E, Trattnig S, Gruber S [2009] Magn Reson Med 62:574–582.

[4] Vandenborne K, Walter G, Leigh JS, Goelman G [1993] Am J Physiol 265:C1332–13329.