Recovery kinetics throughout successive bouts of various exercises in professional road cyclists

D. Bendahan[1], F. HUG[2,3], Y. Le Fur[1], L. Grélot[3], and P. J. Cozzone[4]

[1]UMR CNRS n°6612, University of Aix-Marseille II, Marseille, France, [2]Laboratory JE 2438, University of Nantes, Nantes, France, [3]UPRES EA 3285, University of Aix-Marseille II, Marseille, France, [4]UMR CNRS n°6612, University of Aix-Marseille II, Marseille, France, Metropolitan

Introduction: Over the last 20 years, 31-phosphorus magnetic resonance spectroscopy (^{31}P-MRS) has been used as a noninvasive tool in order to investigate muscle energetics. Given the possibility of monitoring changes in pH and high-energy phosphate compounds such as inorganic phosphate (Pi), phosphocreatine (PCr) and ATP during and after exercise and considering that similar results were obtained as compared to biopsy studies, muscle energy metabolism has been investigated in a variety of conditions ranging from metabolic myopathies to training. However, very few ^{31}P-MRS studies have been conducted in elite sportsmen. In addition, due to methodological limitations (*i.e.* exercise performed inside the magnet) exercises performed by these athletes for the purpose of the metabolic investigations have been very different from ecological situations. On that basis, we found interesting to document the metabolic changes associated with three various exhaustive and specific cycling exercises (i.e. progressive, constant-load and sprint exercise) in a population of professional road cyclists as compared to moderately trained subjects. We analyzed the corresponding results in relation to possible adaptive mechanisms related to a high volume of endurance training.

Methods: 7 Professional Road Cyclists (VO_2max = 74.3 ± 3.7 mL.min-1.kg-1; Maximal Power Tolerated: 475 ± 18 Watts; training volume 22 ± 3 hours/week) and 7 Sport Sciences Students (VO_2max: 54.2 ± 5.3 mL.min-1.kg-1; Maximal Power Tolerated: 341 ± 26 Watts; training volume 6 ± 2 hours/week) performed 3 different exhaustive cycling exercise bouts (i.e. progressive, constant-load and sprint) on an electrically-braked cyclo-ergometer positioned near the 1.5T Siemens Vision Plus MR scanner. Less than 45s after the completion of each exercise bout, recovery kinetics of high-energy phosphorylated compounds and pH were measured in consecutive ^{31}P-MR spectra recorded at a 2s time-resolution. End-of-exercise PCr and pH values were extrapolated at time-zero using regression methods. Because no reliable fitting method exists for PME and Pi, we have directly compared the values measured one minute after the end of each exercise.

Results: Phosphomonoesters (PME) and phosphodiesters (PDE) resting values were significantly elevated in the cyclist group (PME/ATP: 0.82±0.11 vs. 0.58±0.19 and PDE/ATP: 0.27±0.03 vs. 0.21±0.05). At end of the first exercise bout, PCr consumption amounted to 6.5±3.2 and 10.4±1.6 mM in cyclists and control subjects respectively while [Pi] reached 1.6±0.7 mM in cyclists and 6.8±3.4 mM in controls. Similarly, PCr consumption and Pi accumulation were significantly reduced at end of the third exercise bout. During the recovery period following each exercise bout, the pH recovery rate was significantly larger in highly-trained subjects while the PCr recovery kinetics were significantly faster for Professional Road Cyclists only for Bout 3 (Figure 1). After a minute of recovery, [Pi] was significantly higher in moderately trained subjects as compared to professional road cyclists (bout 1: 6.8±3.4 vs. 1.6±0.7 mM (p=0.002); bout 2: 5.5±2.8 vs. 1.7±0.5 mM (p=0.004); Bout 3: 7.7±3.3 vs. 1.5±0.5 mM (p=0.0003)). This significant difference remained until the end of the recovery period for the third exercise bout (4.39±0.8 vs. 2.9±0.3 mM (p=0.001) for sport science students and professional road cyclists respectively) (Figure 1).

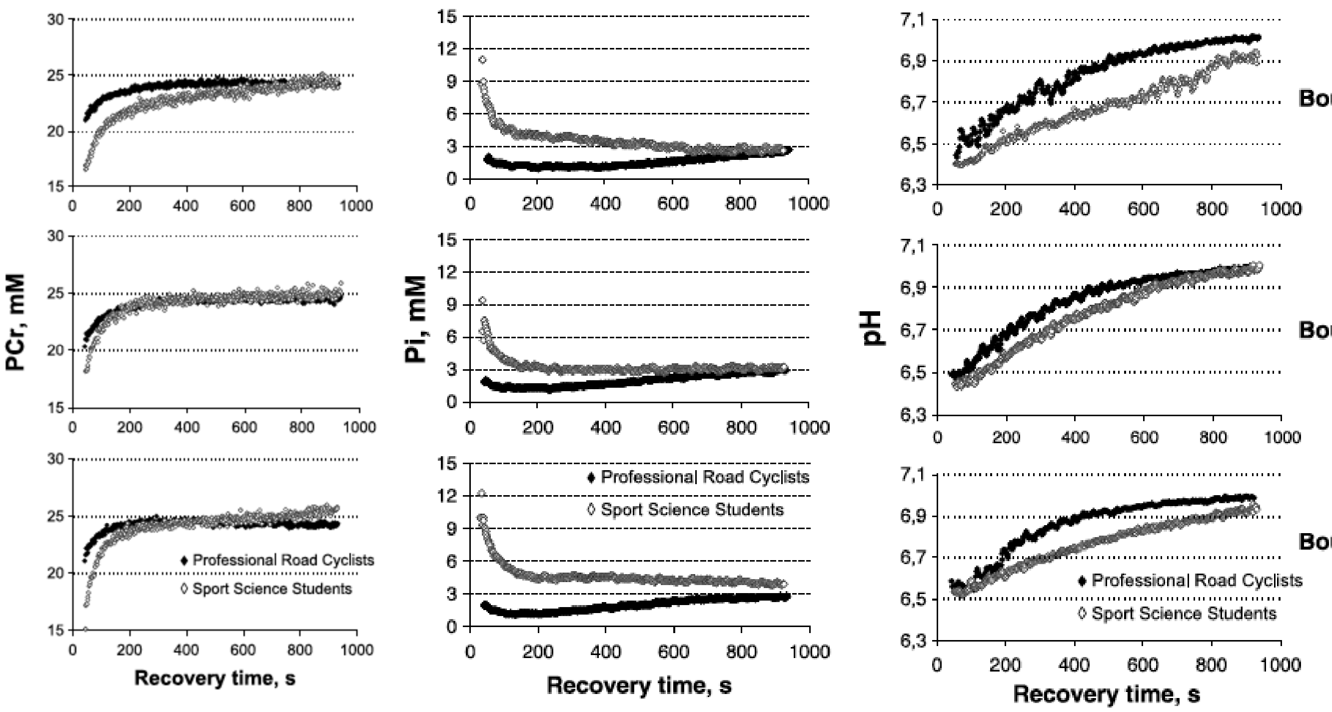

Figure 1: [PCr], [Pi] and pH time-dependent changes for both groups and the three bouts during the recovery period. Error bars have not been added for the sake of clarity.

Conclusion: In the present study, we documented for the first time that intracellular acidosis is large at end of three different exhausting cycling exercises and not significantly different between professional road cyclists and moderately trained subjects. The clearest effects of the superior aerobic capacity in highly-trained subjects are linked to a reduced PCr consumption and Pi accumulation and a faster pH recovery. Our study further confirms that ^{31}P-MRS data characterizing muscle energetics can make it possible to discriminate between two groups of subjects with different training status. Further investigations are needed to study the sensitivity of ^{31}P-MRS measurements to follow-up on the efficiency and adequacy of a specific training program in the course of a cyclist's season.