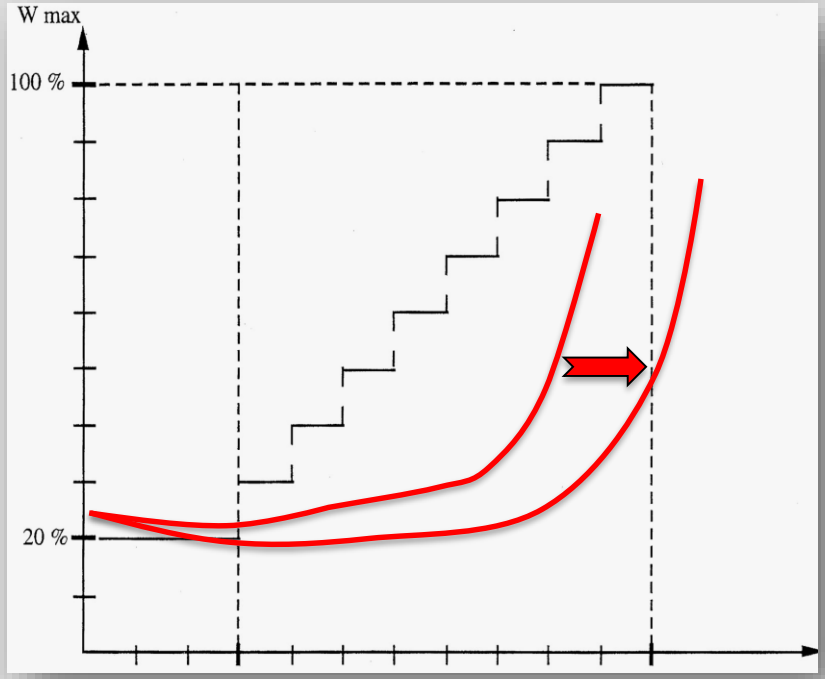
Modeling the energy metabolism of best performances in professional cycling

Sebastian Weber

Back in the days…



Model: muscular energy metabolism as a function of the power output

Metabolic recovery after exercise and the assessment of mitochondrial function in vivo in human skeletal muscle by means of 31P NMR.

Arnold J Biol Chem. 1983 Sep 10;258(17):10464-73.

Evaluation of the relationship between the intra- and extramitochondrial [ATP]/[ADP] ratios using phosphoenolpyruvate carboxykinase.

Wilson DF, E Med Sci Sports Exerc. 1994 Jan;26(1):37-43.

Factors affecting the rate and energetics of mitochondrial oxidative phosphorylation.

Wilson DF[1].

PLoS One. 2012;7(3):e34118. doi: 10.1371/journal.pone.0034118. Epub 2012 Mar 28.

Prediction of muscle energy states at low metabolic rates requires feedback control of mitochondrial respiratory chain activity by inorganic phosphate.

Schmitz JP[1], Jeneson JA, van Oorschot JW, Prompers JJ, Nicolay K, Hilbers PA, van Riel NA.

Author information

Magn Reson Med. 1986 Feb;3(1):44-54.

Energetics of human muscle: exercise-induced ATP depletion.

Taylor DJ, Styles P, Matthews PM, Arnold DA, Gadian DG, Bore P, Radda GK.

Am J Physiol. 1999 Nov;277(5 Pt 1):E890-900.

Regulation of skeletal muscle glycogen phosphorylase and PDH during maximal intermittent exercise.

Parolin ML[1], Chesley A, Matsos MP, Spriet LL, Jones NL, Heigenhauser GJ.

Author information

Am J Physiol. 1997 Jul;273(1 Pt 1):C306-15.

Activation of glycolysis in human muscle in vivo.

Conley KE[1], Blei ML, Richards TL, Kushmerick MJ, Jubrias SA.

Author information

J Appl Physiol (1985). 1998 Dec;85(6):2140-5.

Recovery of free ADP, Pi, and free energy of ATP hydrolysis in human skeletal muscle.

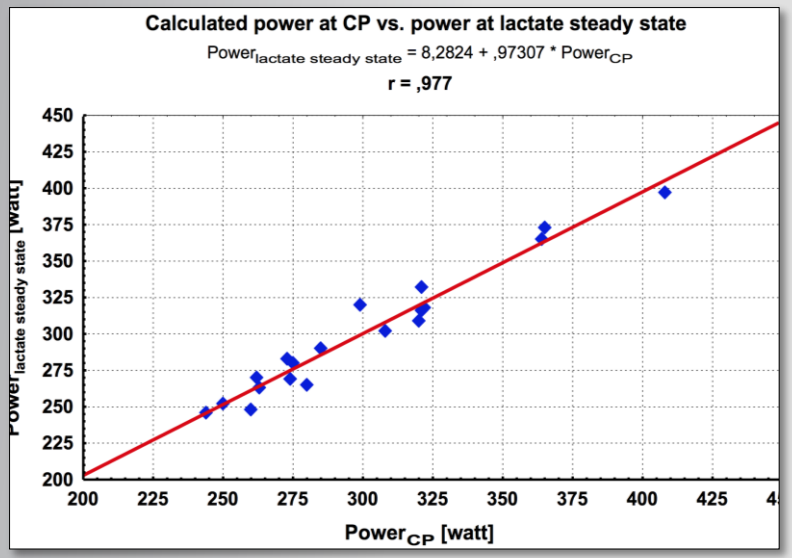
Wackerhage H[1], Hoffmann U, Essfeld D, Leyk D, Mueller K, Zange J.

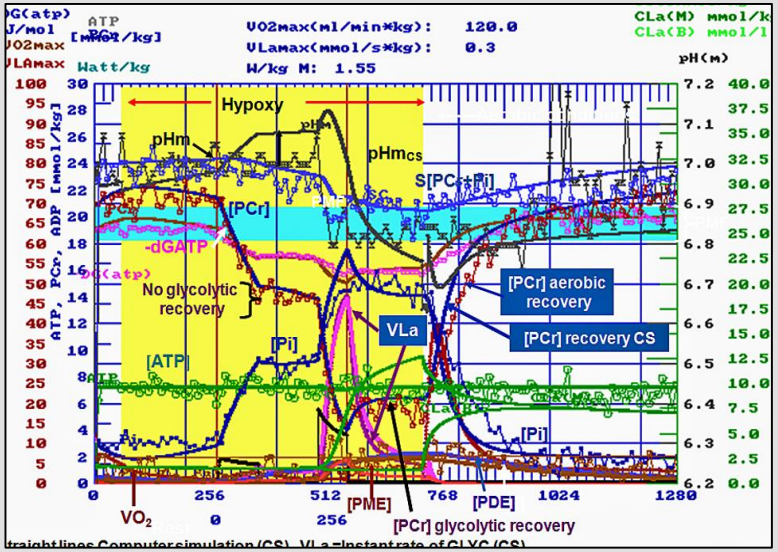
Author information

Abstract

We measured significant undershoots of the concentrations of free ADP ([ADP]) and Pi ([Pi]) and the free energy of ATP hydrolysis (DeltaGATP) below initial resting levels during recovery from severe ischemic exercise with 31P-nuclear magnetic resonance spectroscopy in 11 healthy sports students. Undershoots of the rate of oxidative phosphorylation would be predicted if the rate of oxidative phosphorylation would depend solely on free [ADP], [Pi], or DeltaGATP. However, undershoots of the rate of oxidative phosphorylation have not been reported in the literature. Furthermore, undershoots of the rate of oxidative phosphorylation are unlikely because there is evidence that a balance between ATP production and consumption cannot be achieved if an undershoot of the rate of oxidative phosphorylation actually occurs. Therefore, oxidative phosphorylation seems to depend not only on free [ADP], [Pi], or DeltaGATP. An explanation is that acidosis-related or other factors control oxidative phosphorylation additionally, at least under some conditions.

Validation & Application

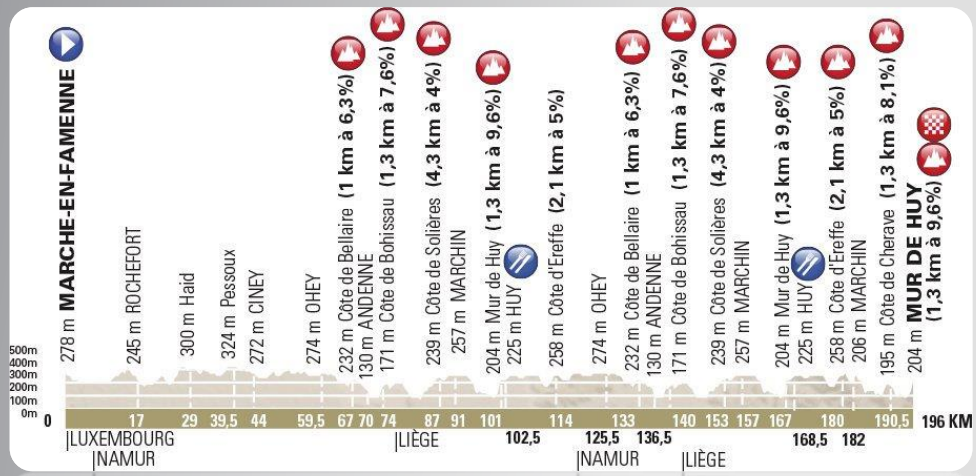




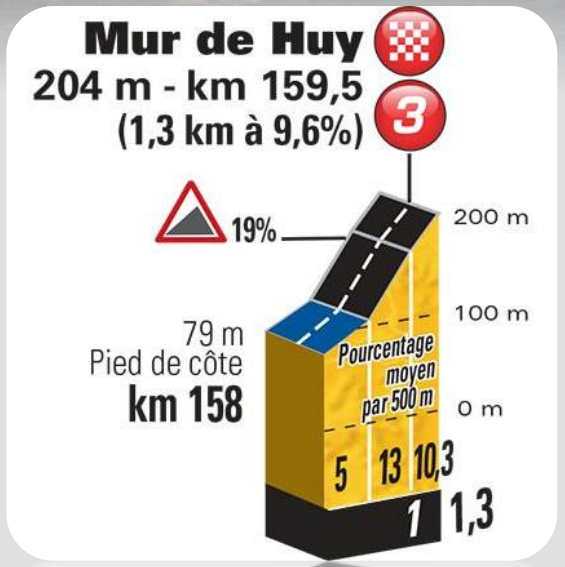
Applications

- Pacing in TT
- Analyze energy sources for given CP data
- Estimate capacities of the competition
- Metabolic demands of a race
- Data manipulation to understand margins
- Metabolic kinetics in interval training

La Flèche Wallone ...?



...unique final climb!

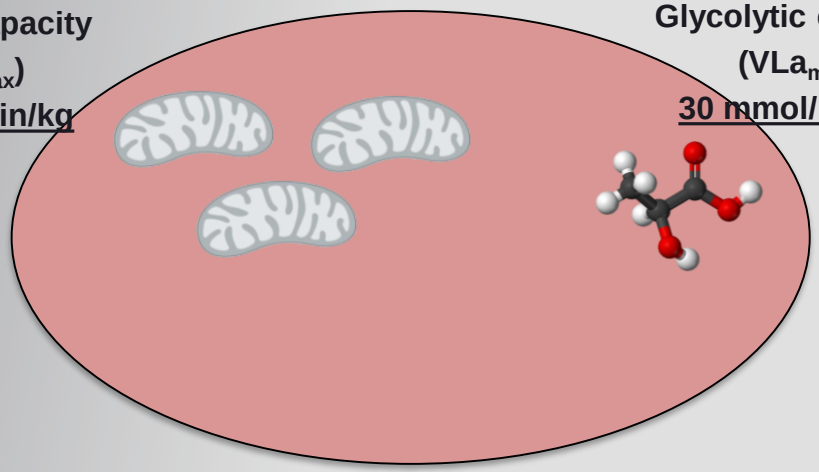


...8 years of working experience!

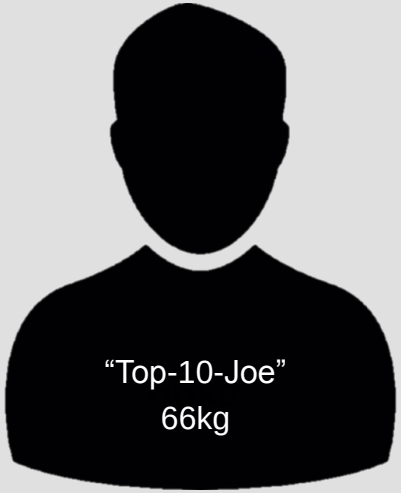
Finale: Power & Speed

Athlete “Top-10-Joe”: measured metabolic capacities

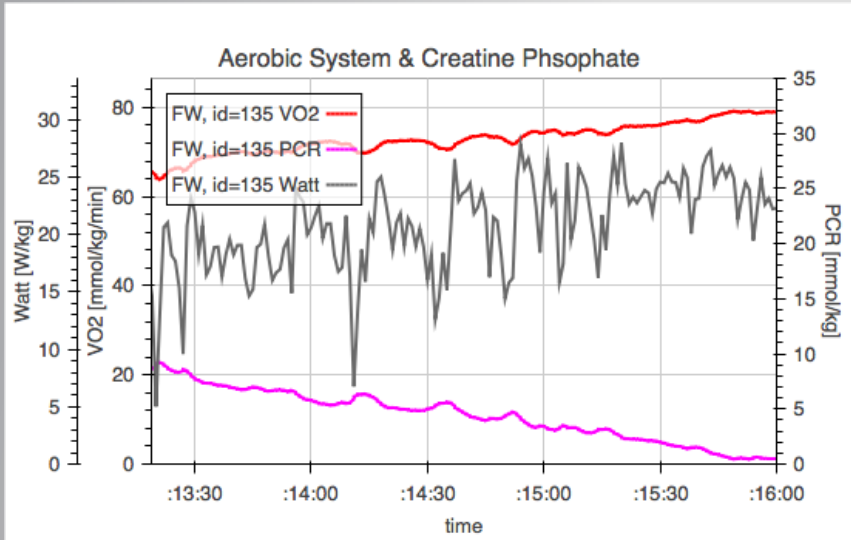
Aerobic capacity
(VO_{2max})
80.5 ml/min/kg

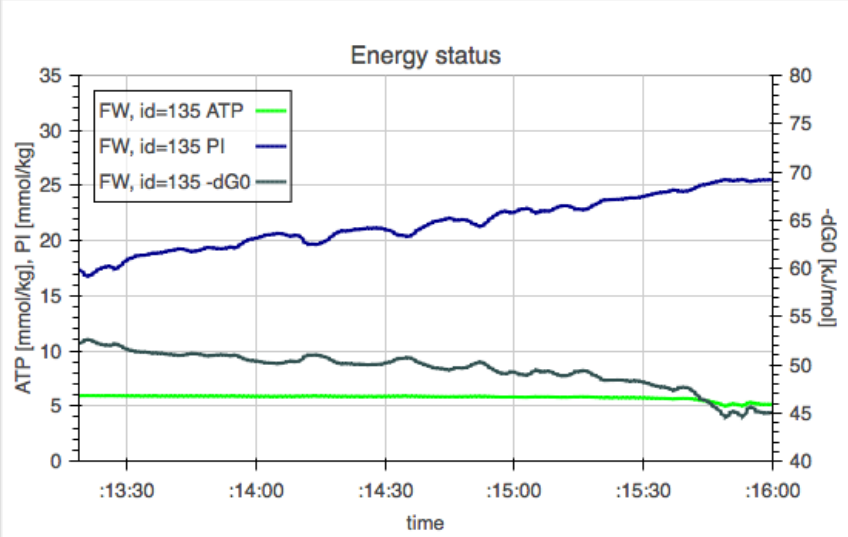


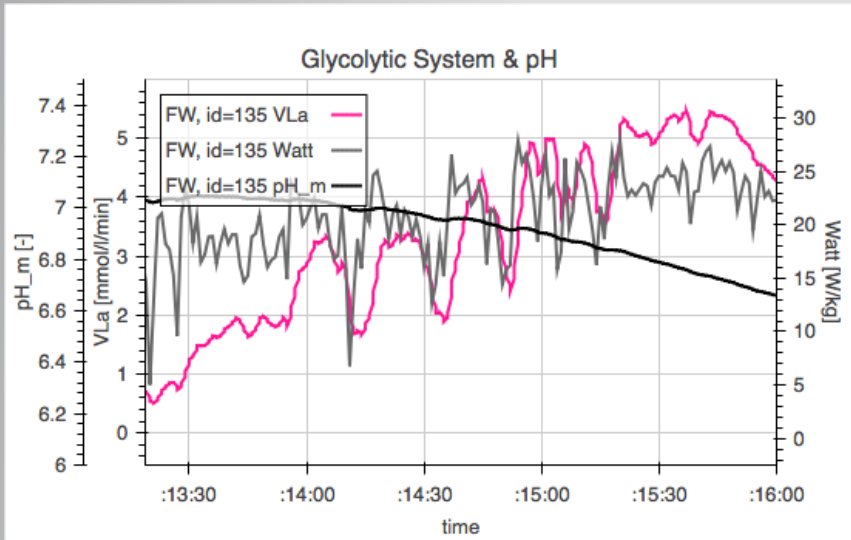
Glycolytic capacity
(VLa_{max})
30 mmol/min/kg

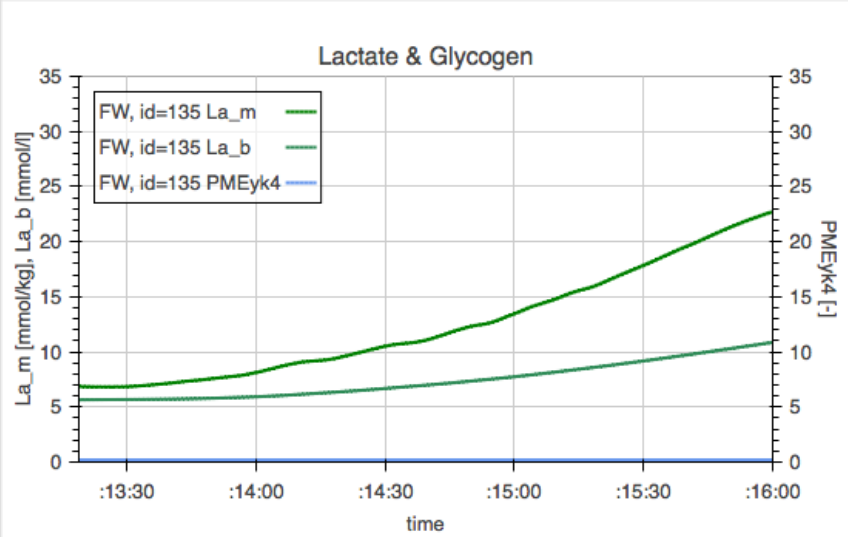


Muscle Energetics in the final 3': Mur de Huy

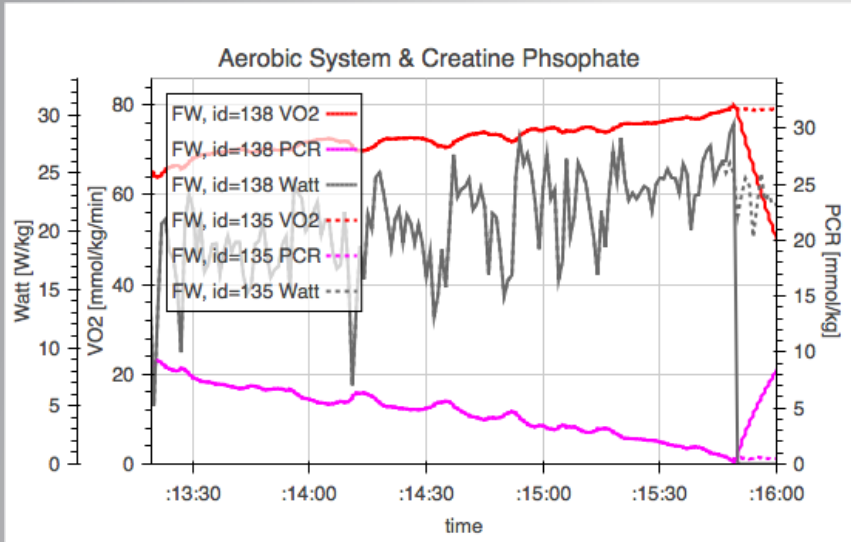


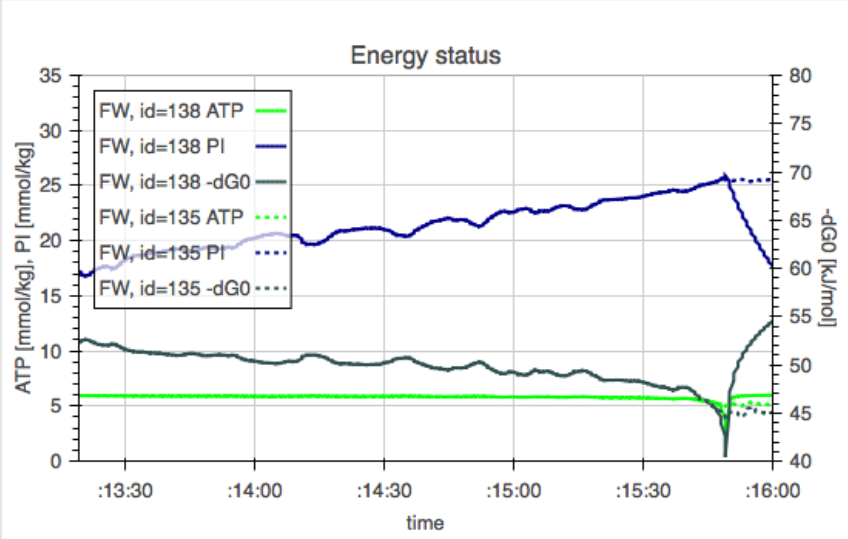


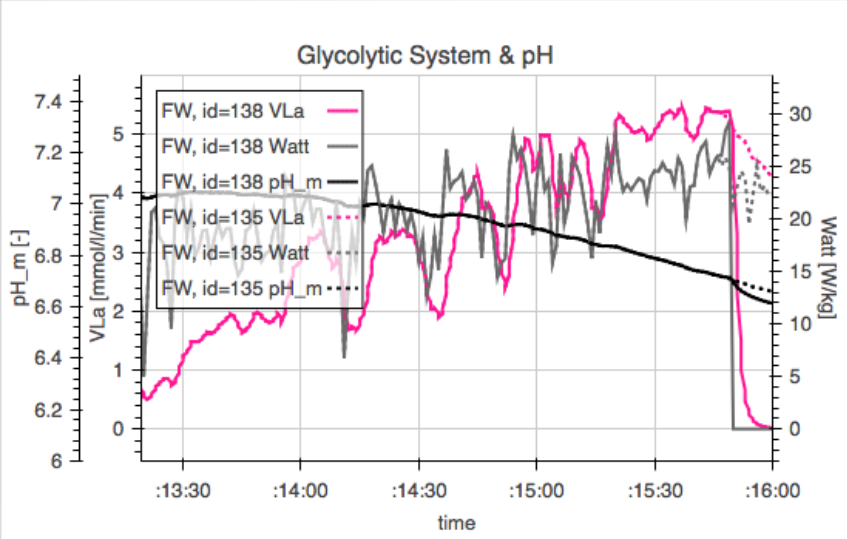


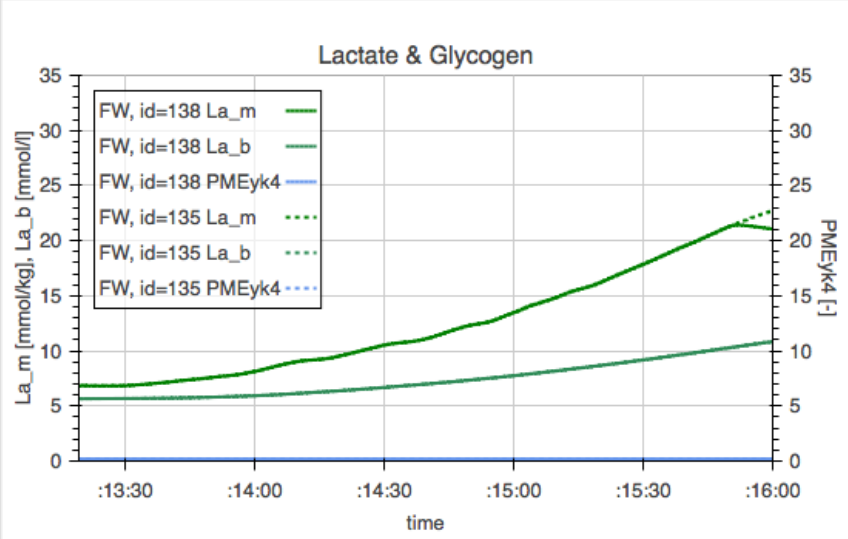


Lets try a sprint ...!

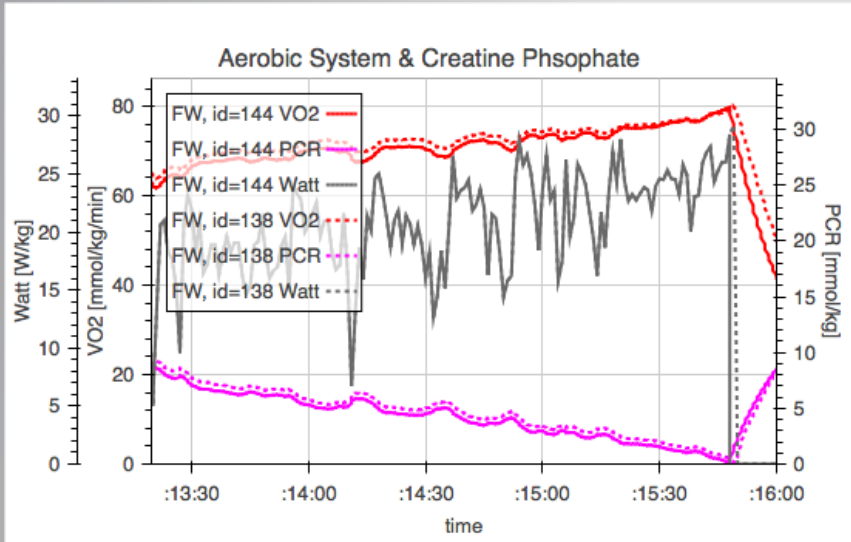


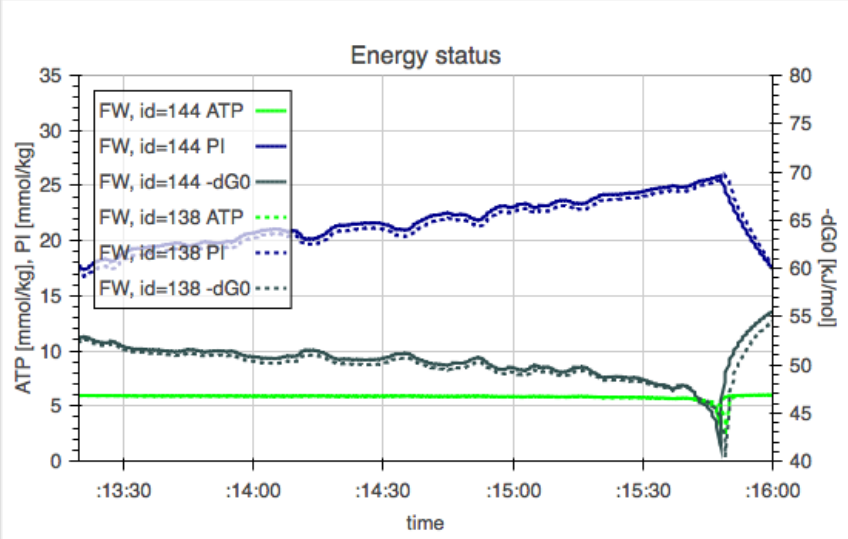


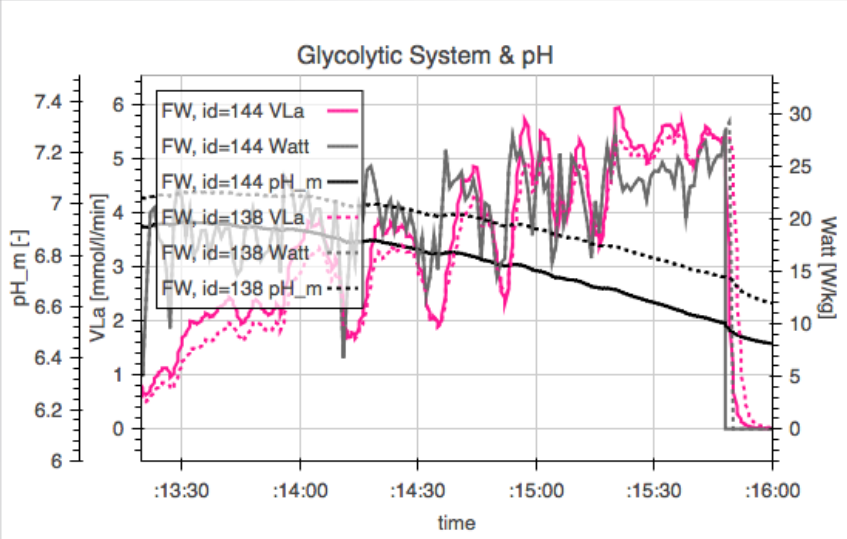


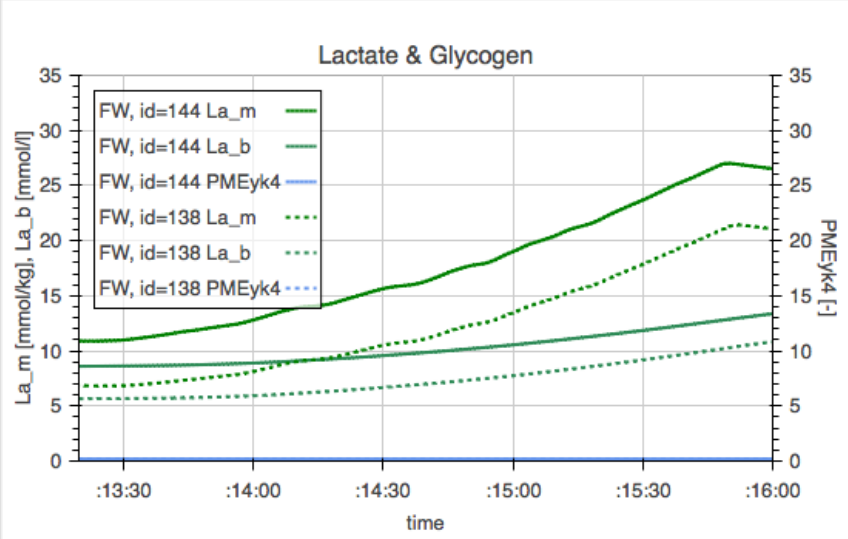


Higher **glycolytic** capacity: 30 (**dotted**) → 66 (**bolt**) mmol/min/kg

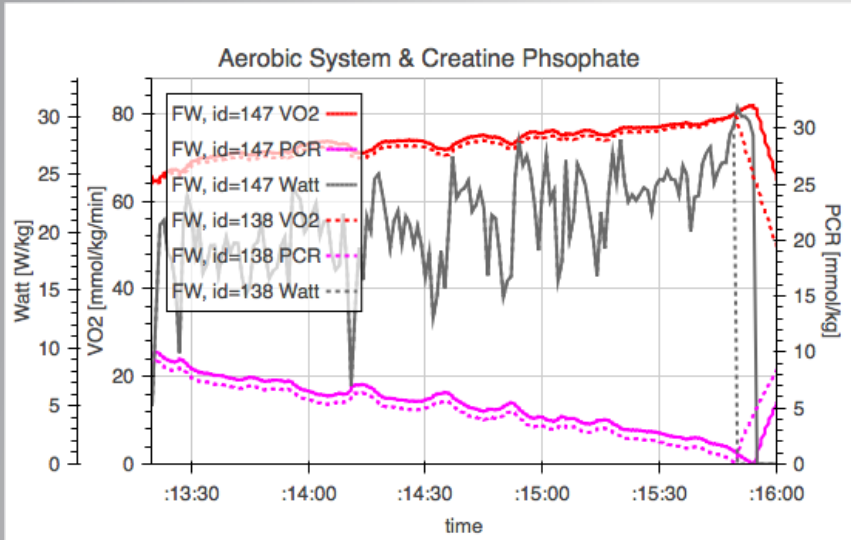


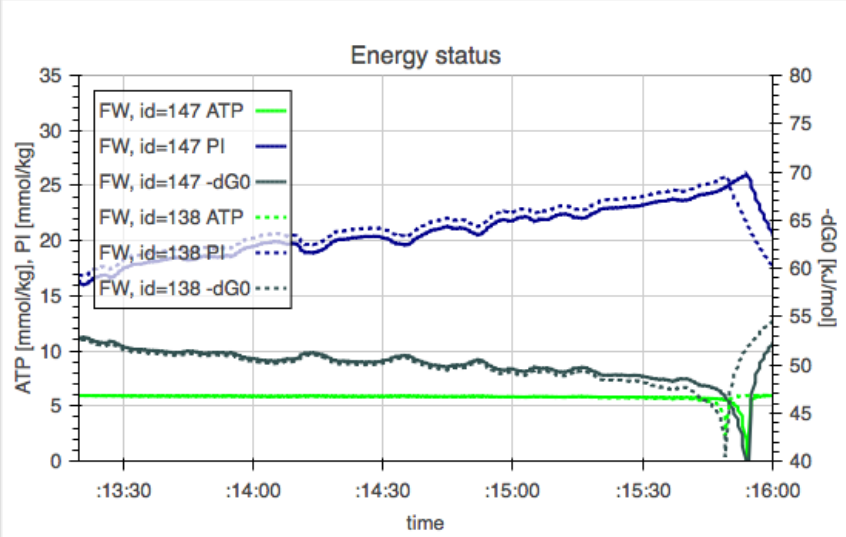


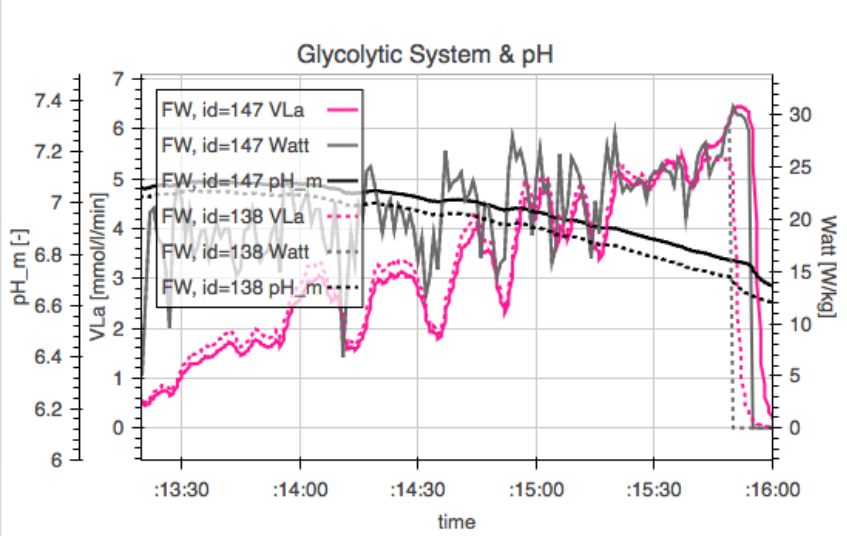


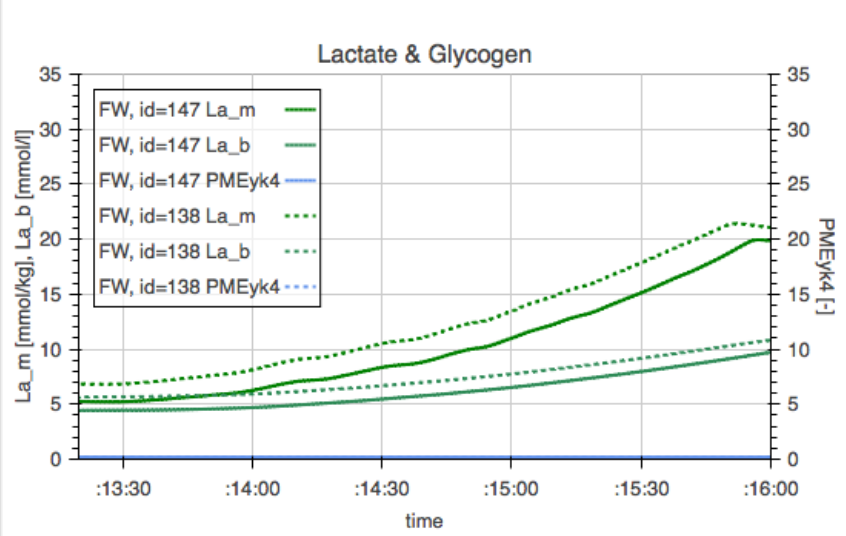


Influence of higher aerobic capacity: 80.5 (**dotted**)→ 82.5 (**bolt**) mmol/min/kg



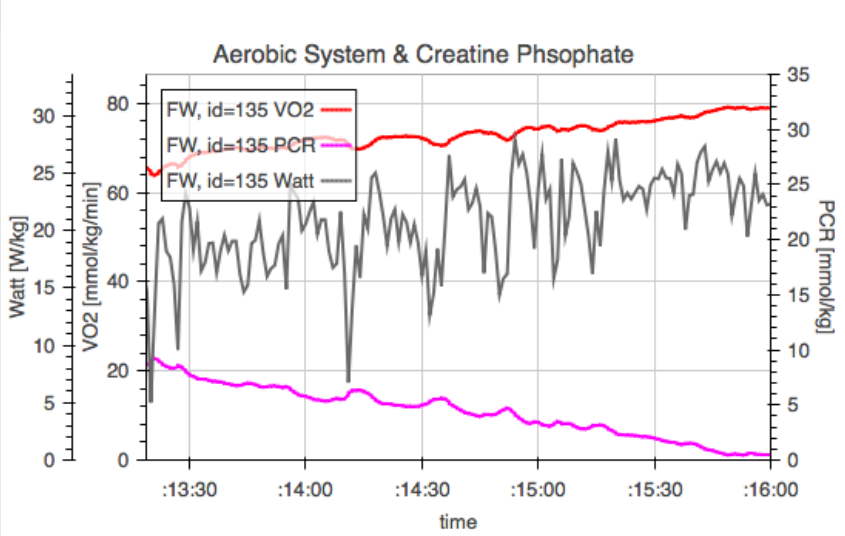


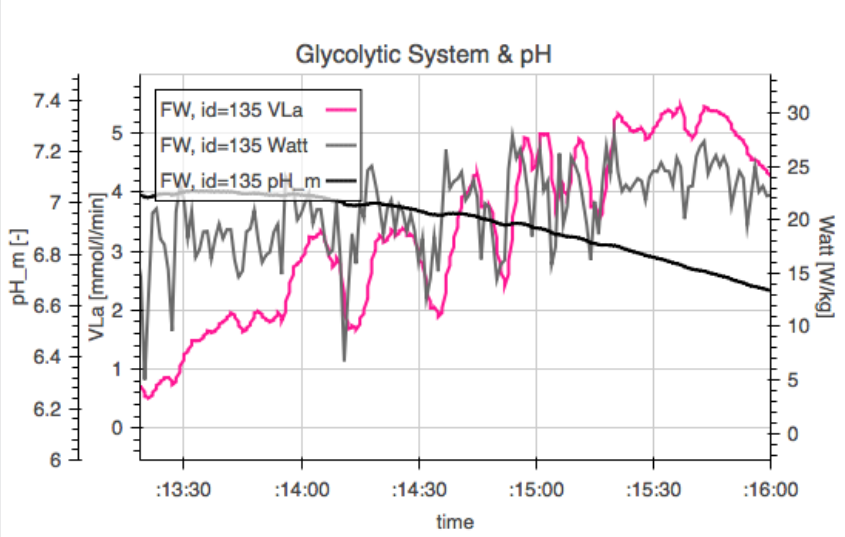




“Top-10-Joe:

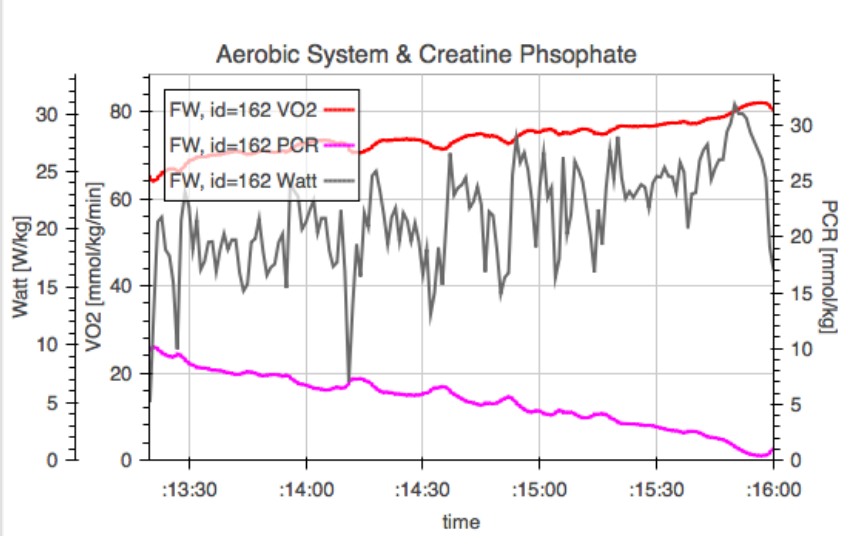
aerobic: 80.5 ml/min/kg & glycolytic: 30 mmol/min/kg

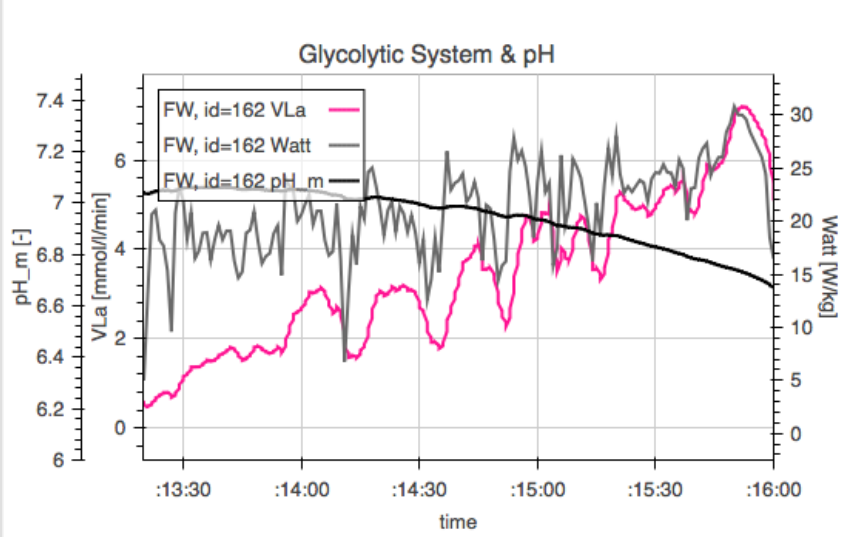




“Winning-Joe:

aerobic: 83.0 ml/min/kg & glycolytic: 39 mmol/min/kg





Thank you!

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