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Modelling the energy metabolism of best performances in professional cycling

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Abstract

It is widely accepted that the muscular energy metabolism is of primary importance for best performances in professional cycling. However the dynamics of the muscular energy metabolism can neither get accessed directly nor measured adequately during actual race situations.

A mathematical model, which enables to simulate muscular energy metabolism as a function of the power output, has been successfully applied in particular events in professional cycling since the victorious time of Team High Road in 2008 and its successors. Those simulations have been used to better understand the underlying mechanisms in particular race situations, to formulate a differentiated work demand, for pacing in time trials and for talent identification.

Two specific events have been selected for simulations: a team time trial of the “Critérium du Dauphiné” and the final of “La Flèche Wallone”.

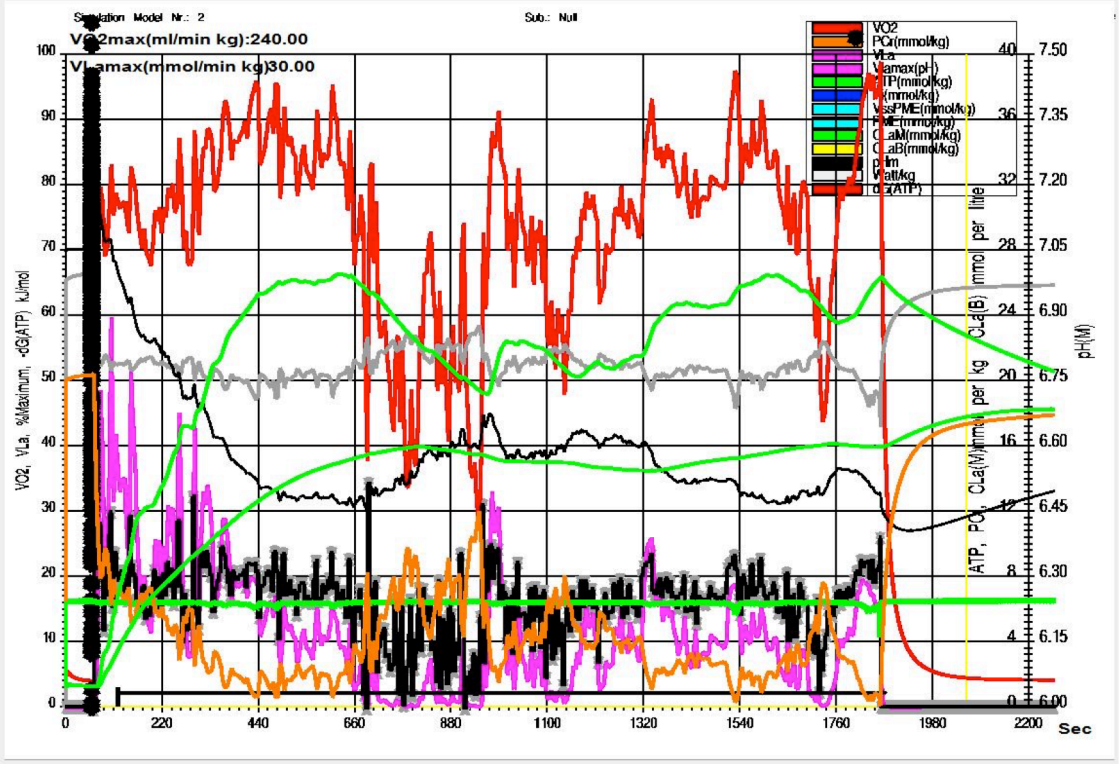
The time trial consisted of a 24,5km route with two climbs: one at 8km and the second one at 24,5km. The basic physiological values of the athlete have been recorded in a lab. The actual power output during the race was measured using a SRM powermeter.

The simulation shows that muscle lactate levels were critical high (20-25 mmol/kg) without any sufficient recovery throughout the whole race. As expected highest level have been calculated during the two ascents. Furthermore several moments during the race could be identified when the calculated free energy levels of the muscle decrease to a level close to exhaustion. These situation could not be linked to the actual topography of the race, nor was the power output on these particular moments significant higher then at other parts of the race, when the exhaustion was less. In fact the model shows how the drop in free energy resulted from the complex interaction of muscle pH, VO2 demand, creatine phosphate concentration and rate of glycolysis. The power output itself did not provide any hindsight to these crucial moments.

The race “La Flèche Wallone” includes the final called “Mur du Huy”, a climb of 1,3km to the finish. The race is often won in a final acceleration or sprint, requiring a high power output towards the end of the climb. As a first approach, a generic athlete was chosen to simulate this particular race final. The results showed increasing VO2 and lactic acid levels combined with decreasing pH and creatine phosphate levels as a result of the required high power output. Furthemore the calculated free energy of the muscle dropped to a level below 50 kj/mol, preventing the possibility for a higher power output as needed in a sprint. In order to understand the influence of the metabolism on the result, anaerobic and aerobic capacities were altered in several iterations.

The results of this iterations showed that a improvement in aerobic or anaerobic performance alone would not be sufficient. Only the combined alternations of both capacities, to a certain extend, would enable the athlete to succeed.

Even though any simulation provides only an approximation of the reality, the concept can be seen as a useful tool to better understand requirements and the dynamic of the energy metabolism. This knowledge can be seen as crucial for the creation of training programs and pacing strategies.



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