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Case Study – 24 Hr Mountain Biking and Substrate Oxidation Estimates

By Alan McCubbin

In October 2014, a mountain biker walked into my office. After finishing eighth in the 2013 24 hour solo world championships, she wanted help to make the top five in 2015. Her story was similar to many ultra-endurance athletes – in trying to push her carbohydrate (CHO) intake to 60g/hr, she experienced significant gastrointestinal (GI) distress and flavour fatigue. She was worried that this was limiting her potential performance.

Guidelines for endurance racing suggest CHO intakes of up to 90g/hr for events lasting longer than three hours (1). But in 24 hour racing the relative exercise intensity is significantly lower than shorter events. I'd long wanted to try a similar methodology in a 24 hour rider to that found in an Ironman case study, where the authors estimated energy expenditure and substrate oxidation from lab data (2). Now I had my chance.

My Client: A 34 year old female mountain biker, 151cm tall, 45kg with a VO2max of 71.4mL/kg/min. She had completed several 24 hour solo events before. Her habitual diet typically contained 6-7g/kg/ day of CHO with no food allergies, intolerances or aversions. She had previously experienced both upper (nausea and reflux) and lower (intestinal cramps and flatulence) GI symptoms during 24 hour races to a moderate extent, but never failed to finish because of it.

24 Hour Mountain Bike Racing: A 24 hour solo mountain bike race requires competitors to ride a loop circuit, completing as many laps as possible within the 24 hours. Riders and their support crew set up "pits" – a tent in the start/finish area where support crew can assist by providing food and fluids, mechanical repairs and other forms of assistance. Assistance cannot be provided outside this pit area.

Estimating Substrate Use from Previous Race Data

Whilst I would have liked to employ the methodology used by Cuddy et al. in their case study of an Ironman athlete (2), as a private practitioner this was not an option. Like many mountain bikers my client does not use a power meter. Instead I had to use heart rate data from two previous races and pair it with data obtained from an incremental ergometer test.

The incremental ergometer test was performed on a Watt bike in a private lab, 14 days prior to one of the races where data was obtained. Throughout the test non-protein oxidation rates were determined from indirect calorimetry, using the equations of Péronnet and Massicotte (3). Because substrate use is known to change with increasing exercise duration (4), the test was performed following four hours of training to better simulate race conditions.

Race heart rate data was analysed in quintiles. Quintiles were calculated from the lowest measured heart rate to HRmax. The proportion of time spent in each quintile is shown in Figure 1, obtained using the training zone functionality from Training Peaks.

To estimate the substrate use for optimal race performance (rather than merely replicating previous performances), a hypothetical goal race was constructed whereby time spent in the lowest two quintiles was reduced by 6 and 8%, and time in quintiles 3 and 4 increased by the same amount. Additional time was not added to the highest HR quintile, because the time spent in this quintile (<30min in both races) only occurred during the first lap, due to a running start and jockeying for position in the early stages of the race.

Substrate oxidation rates were estimated using the mean of all increments within each HR quintile during the ergometer test. Combined with the time spent in each quintile, total energy expenditure, fat and CHO oxidation was calculated for both previous races and the hypothetical goal race.

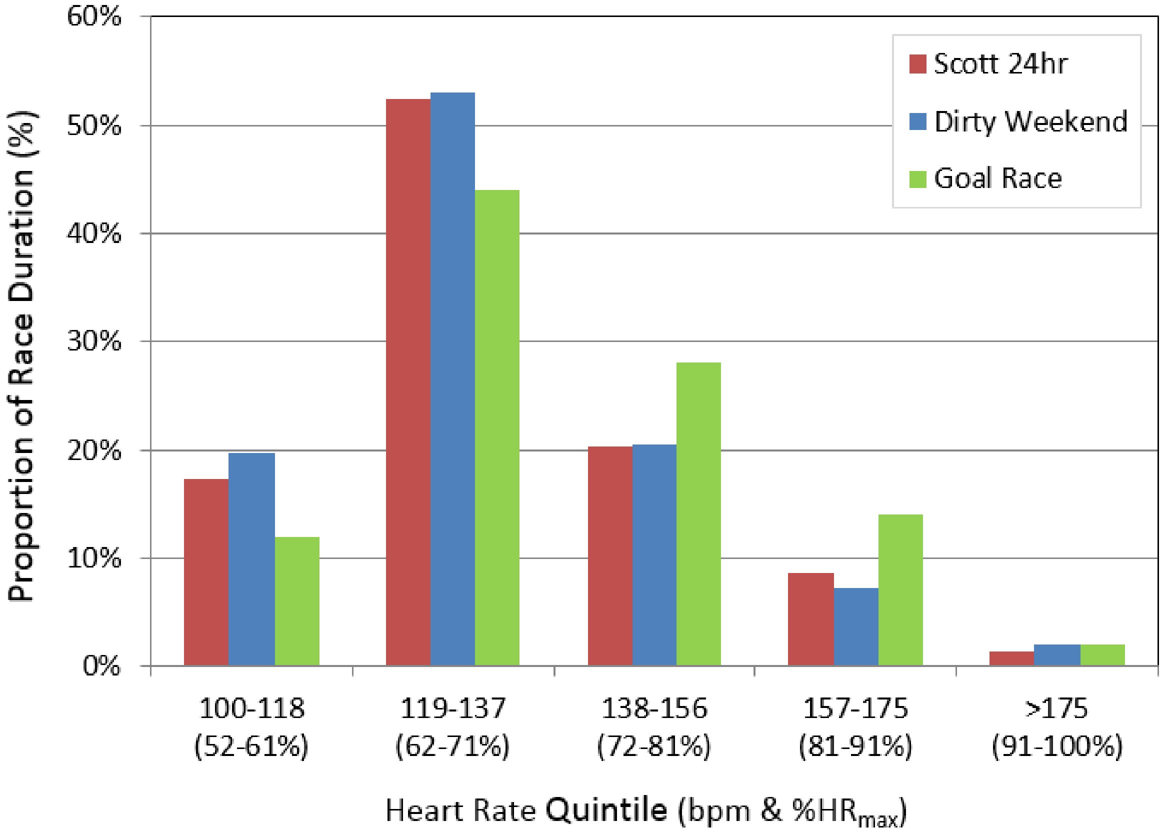

Figure 1. Proportion of race time spent in each HR quintile for the Scott 24 hr(Oct 2014), the Dirty Weekend (May 2015) and the hypothetical Goal Race.

Findings

Estimated energy expenditure in the races was 37,424kJ and 35,798kJ, increasing to 41,857kJ for the hypothetical goal race. Estimated energy expenditure and substrate oxidation rates are shown in Figure 2. The most interesting finding was that the estimated total carbohydrate oxidation rate was less than 0.5g/min (30g/hr), well below ingestion recommendations for ultra-endurance athletes (1) and below what the client had been trying to ingest previously. Even in the hypothetical scenario, estimated total carbohydrate oxidation was only 0.56g/min (33.7g/hr).

Race Strategy

Our race plan was to complete a traditional carbohydrate loading the day before the race, ensuring adequate carbohydrate availability for the first few hours of the race when the pace would be the highest. The during-race carbohydrate ingestion target was 47g/hr (the estimated oxidation rate, plus a 30% buffer in case the method had underestimated). Being less than 60g/hr, multiple transportable carbohydrates were deemed unnecessary – this allowed us to focus on milder and savoury options by not planning around the use of fructose, minimising the risk of flavour fatigue. Fluids consisted of electrolyte tablets (for flavour) with maltodextrin to provide carbohydrate but minimise sweetness. Cola was also consumed overnight for both variety and caffeine. Other options included:

- Homemade gels prepared in 115mL flasks using water, maltodextrin, salt and lemon juice
- Lady finger bananas
- A small serve of risotto in the early evening
- Instant mash potato "gel" (mash potato powder, maltodextrin and stock mixed into a thick gel consistency)
- Vegemite sandwiches (an Aussie savoury classic)

Outcomes

The client finished fourth. Although she secretly hoped to make the podium, overall she was satisfied with her performance, feeling it was "the best possible race I could have ridden, and would not have been achievable one year ago". There were no mechanical issues, she spent less than ten minutes in the pits for the entire race, and was very happy with her nutrition. She never felt hungry or full and experienced no GI distress or flavour fatigue. Subjective energy levels were good despite the lower CHO intake compared to previous races. Unfortunately due to a malfunction race HR data was not saved and could not be analysed.

Detailed records of food and fluid consumption were kept by her race crew. Overall CHO ingestion was 44g/hr for the race duration, following the suggested plan with few variations.

Limitations of this methodology

Whilst this method of estimating substrate oxidation and energy expenditure was insightful, it is important to acknowledge that it has not been validated against actual measurements using indirect calorimetry. This could be achieved with a portable indirect calorimeter that can be worn whilst mountain biking (as used in the Ironman case study of Cuddy et al. (2)), an option I am interested to explore. However, due to the significant cost it was not feasible in this instance. If anyone has access to such a unit and is interested in developing a methodology for estimating substrate use from race data, I would be very interested to hear from you.

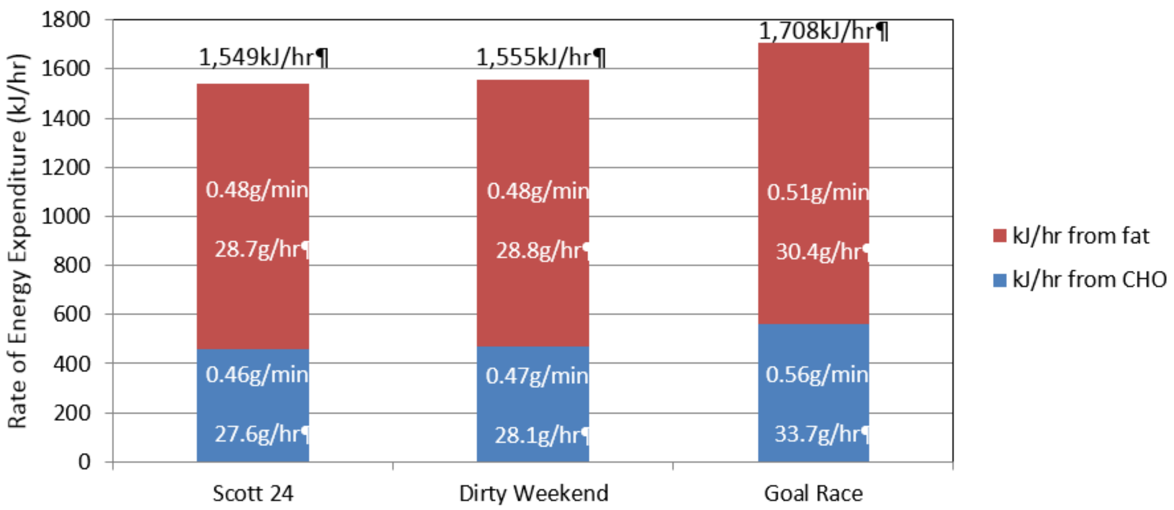

Figure 2. Estimated total energy expenditure (kJ/hr), carbohydrate and fat oxidation (g/min and g/hr) for the Scott 24hr (Oct 2014), Dirty Weekend (May 2015) and the hypothetical Goal Race.

The ergometer test itself used increments of only two minutes at each intensity – ideally we would have used longer steady state periods. I also would have preferred power rather than heart rate data for the analysis, but the client did not own a power meter.

The terrain of every mountain bike course is also different, and this may affect pacing strategy and substrate oxidation, making extrapolation from one race to another difficult. Having said that, data from both previous races yielded remarkably similar results despite being raced on two completely different courses.

Finally, whilst the incremental test was conducted after four hours of training, it is likely the substrate mix would have differed after 15-20 hours of racing, and has not been accounted for here.

Conclusions

From this estimation of substrate use during 24hr solo mountain bike racing (and despite the stated limitations), it would appear that this particular athlete did not need to ingest CHO at the levels suggested in guidelines for endurance sport (1). Determining individual CHO needs for ultra-endurance athletes for each specific event type would assist in optimising performance, whilst minimising the risk of GI distress or flavour fatigue. Validation of an affordable and accurate method would be a significant benefit to endurance nutrition practitioners and athletes alike.

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