PERSPECTIVES

A high carbohydrate diet remains the evidence based choice for elite athletes to optimise performance

J. W. Helge
Center for Healthy Aging, Department of Biomedical Sciences, University of Copenhagen, Denmark
Email: jhelge@sund.ku.dk

Fat loading or simply consuming a diet rich in fat has been used for more than 100 years to manipulate substrate oxidation both at rest and during exercise. Pioneering work by Christensen & Hansen in the late 1930s clearly demonstrated the link between exercise performance and substrate oxidation and provided early evidence that short term carbohydrate diet consumption enhanced endurance performance (Christensen & Hansen, 1939).

The seminal studies performed in Stockholm in Sweden in the 60s by Bergström *et al.* (1967) reintroduced the needle muscle biopsy technique and very forcefully demonstrated the associations between depletion of muscle glycogen and the development of fatigue during endurance exercise. Founded on these studies major efforts were undertaken to study procedures that could optimise muscle glycogen storage and attenuate glycogen breakdown to increase endurance performance. Over time this led to the dietary recommendations for endurance athletes that are probably most common among endurance athletes today; a high carbohydrate, moderate protein, low fat diet optimised for micronutrients, dietary fibre and consumed in a timely fashion. To further optimise endurance training adaptations in muscle and whole body and to cater for individual differences, this dietary practice is often combined with the specific training practice including a number of procedures such as dietary cycling (fasting/fed and/or micro/macro cycles), sleep manipulation, timing of meals (before and after training), sequential exercise bouts (train low/high) to name the most common procedures.

However, in recent years this approach has been challenged by applications of keto adaptation that uses very high fat and moderate protein diets almost devoid of carbohydrates to induce nutritional ketosis (Volek *et al.* 2015). Historically this diet is well tested and tolerated by our ancestors and in more recent times in the Arctic by Inuit and explorers during exercise under strenuous conditions. The underlying idea behind keto adaptation is obviously the almost non-limited availability of fatty acids during exercise that negates the muscle glycogen depletion and abolishes the need for carbohydrate supplementation during exercise. Yet although evidence has emerged that long term keto adapted ultra-endurance-athletes are capable of oxidising large amounts of fat during exercise, up to 1.5 g fat min^{-1}, there is only anecdotal evidence linking this to endurance performance in elite athletes. However, this has not dampened the interest in and application of the keto adaptation regime to potentially optimise performance.

In this issue of *The Journal of Physiology* Burke and colleagues strongly challenge the concept of a positive effect of keto adaptation on endurance performance in elite race walkers (Burke *et al.* 2017). The study applies three isoenergetic lightly hypocaloric diets during 3 weeks of controlled training: a ketogenic very low carbohydrate, moderate protein and high fat diet (LCHF) compared to a classic high carbohydrate diet (HCHO), and a diet with similar macronutrient composition (PCHO), but with alternating consumption before and after training. As expected peak oxygen uptake ($\dot{V}_{O_2 peak}$) during race walking was similarly increased in all three groups and LCHF had a markedly higher fat oxidation during 2 h exercise at 80% $\dot{V}_{O_2 peak}$ compared to HCHO and PCHO. However, the performance time for the 10 km race walk was only improved in HCHO and PCHO, and this occurred concomitantly with a reduced oxygen uptake at 20 km race pace only in HCHO and PCHO. Burke and colleagues elegantly conclude that 3 weeks of intensive training and (keto) adaptation to a ketogenic very low carbohydrate, moderate protein and high fat diet impairs exercise economy and attenuates the training induced performance improvements observed when comparing to the two high carbohydrate diets.

Albeit not fully conclusive due to both the limited study duration of 3 weeks and application of slightly hypocaloric diets, the evidence presented by Burke and colleagues strongly suggests that, in elite athletes training and performing at intensities similar to elite sports competition, keto adaptation is not the optimal dietary choice.

Almost 20 years ago we demonstrated that endurance performance was attenuated during submaximal exercise after 7 weeks of regular endurance training and adaptation to a high fat diet compared to a high carbohydrate diet in untrained males (Helge *et al.* 1996). Interestingly the rate of perceived exertion was higher after high fat compared to carbohydrate diet adaptation, a finding later demonstrated also in trained athletes (Stepto *et al.* 2002). However, the rate of perceived exertion is only a marker and be it high fat diet adaptation or keto adaptation there is still a need to fully understand the mechanisms in muscle and whole body that inevitably control the capacity to attain the full individual training induced endurance exercise performance potential, particularly in elite athletes.

References

Bergström J, Hermansen L, Hultman E & Saltin B (1967). Diet, muscle glycogen and physical performance. *Acta Physiol Scand* **71**, 140–150.

Burke LM, Ross ML, Garvican-Lewis LA, Welvaert M, Heikura IA, Forbes SG, Mirtschin JG, Cato LE, Strobel N, Sharma AP & Hawley JA (2017). Low carbohydrate, high fat diet impairs exercise economy and negates the performance benefit from intensified training in elite race walkers. *J Physiol* **595**, 2785–2807.

Christensen EH & Hansen O (1939). Arbeitsfähigkeit und Ernärung. *Skandinavishes Archiv für Physiolgie* **81**, 160–171.

Helge JW, Richter EA & Kiens B (1996). Interaction of training and diet on metabolism and endurance during exercise in man. *J Physiol* **292**, 293–306.

Stepto NK, Carey AL, Staudacher HM, Cummings NK, Burke LM & Hawley JA (2002). Effect of short-term fat adaptation on high-intensity training. *Med Sci Sports Exerc* **34**, 449–455.

Volek JS, Noakes T & Phinney SD (2015). Rethinking fat as a fuel for endurance exercise. *Eur J Sport Sci* **15**, 13–20.

Additional information

Competing interests

None declared.

DOI: 10.1113/JP273830