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“Fat adaptation” for athletic performance: the nail in the coffin?

ENDURANCE ATHLETES have a high capacity for the oxidation of fat during exercise as a legacy of their training. Therefore, it is intriguing that this capacity can be easily upregulated by the chronic consumption of a low-carbohydrate ($<2.5 \text{ g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$), high-fat ($\sim 65\text{--}70\%$ of energy) diet. For example, 2–4 wk of exposure to such a diet in trained individuals has been shown to markedly increase fat oxidation and reduce the utilization of muscle glycogen during subsequent submaximal exercise (10, 11). Despite the promise of an enhanced ability to “tap into your body fat,” fat loading per se does not seem to lead to a clear enhancement of exercise capacity or performance (for review, see Ref. 8). In fact, there is at least a short-term increase in the perceived effort of training (2, 3) and an impairment of the response to training when the high-fat, low-carbohydrate eating continues for periods longer than 4 wk, based on data from previously untrained individuals (7).

Several more recent studies reignited the interest in fat loading for athletes. Goedecke and colleagues (5) provided a practical option with their observations that an increased fat utilization during submaximal exercise could be achieved in as little as 5 days of training on a high-fat (69% of energy), low-carbohydrate diet. These adaptations were subsequently shown to be consistent and robust, persisting in the face of protocols to increase carbohydrate availability by subsequent restoration of muscle glycogen content with 1 day of rest and the intake of a high-carbohydrate intake ($10 \text{ g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$) (1, 3, 4) or the consumption of carbohydrate before and during a bout of prolonged exercise (3, 4). Such a combination of dietary strategies would seem the perfect competition preparation for an endurance or ultraendurance athlete, simultaneously restoring carbohydrate stores while maximizing the capacity for fat oxidation during submaximal exercise. Interestingly, when carbohydrate loading after dietary fat adaptation is extended beyond 3 days, muscle glycogen stores are supercompensated, and a high-carbohydrate utilization during exercise is achieved (8). Nevertheless, the effect of various “dietary periodization” on exercise performance has remained unclear, with studies reporting benefits (9), no change (1, 3, 4), or impairment (7, 8) to various endurance and ultraendurance protocols. A variety of explanations has been offered to explain the apparent lack of transfer between metabolic changes and performance outcomes (2). They include the failure of scientists to detect small changes in performance that might be worthwhile in real-life sports and the existence of “responders” and “non-responders” to fat-adaptation strategies (1, 11). In addition, adaptations to a fat-rich diet have been shown to increase plasma norepinephrine concentrations and heart rate during submaximal exercise (7), possibly leading to increased perceived effort of exercise training (2, 3). The paper by Havemann and colleagues (6) in the present issue of *Journal of Applied Physiology* adds weight to this possibility.

Previous studies have focused on the metabolic changes occurring with dietary fat adaptation strategies as an indication of the upregulation of fat metabolism. Mechanisms have included increases in putative fatty acid transporters as well as enzymes of lipid metabolism (for reviews, see Refs. 2, 8). However, there is now evidence that what was initially viewed

as “glycogen sparing” after adaptations to a fat-rich diet may be, in fact, a downregulation of carbohydrate metabolism or “glycogen impairment.” One study (12) has reported that fat adaptation/carbohydrate restoration strategies are associated with a reduction in the activity of pyruvate dehydrogenase; this change would act to impair rates of glycogenolysis at a time when muscle carbohydrate requirements are high. The present study of Havemann et al. (6) furthers our knowledge by applying the fat adaptation/carbohydrate restoration model to an endurance cycling protocol that involves several features of a real-life race: self-pacing and the interspersing of high-intensity bouts of cycling with more moderate-intensity segments. The results show that the dietary strategy has no effect on overall performance of a 100-km time trial but compromises the ability of well-trained cyclists to performance high-intensity sprints.

It is tempting to classify endurance and ultraendurance sports as submaximal exercise, which might benefit from increased fat utilization and a conservation of limited endogenous carbohydrate stores. However, the strategic activities that occur in such sports, the breakaway, the surge during an uphill stage, or the sprint to the finish line, are all dependent on the athlete’s ability to work at high intensities. With growing evidence that this critical ability is impaired by dietary fat adaptation strategies and a failure to find clear evidence of benefits to prolonged exercise involving self-pacing, it seems that we are near to closing the door on one application of this dietary protocol. Scientists may remain interested in the body’s response to different dietary stimuli and may hunt for the mechanisms that underpin the observed changes in metabolism and function. However, those at the coal-face of sports nutrition can delete fat loading and high-fat diets from their list of genuine ergogenic aids for conventional endurance and ultraendurance sports.

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