The following is the abstract of the article discussed in the subsequent letter:

Carey, Andrew L., Heidi M. Staudacher, Nicola K. Cummings, Nigel K. Stepto, Vasilis Nikolopoulos, Louise M. Burke, and John A. Hawley Effect of fat adaptation and carbohydrate restoration on prolonged endurance exercise. J Appl Physiol 91: 115–122, 2001.—We determined the effect of fat adaptation on metabolism and performance during 5 h of cycling in seven competitive athletes who consumed a standard carbohydrate (CHO) diet for 1 day and then either a high-CHO diet (11 g·kg⁻¹·day⁻¹ CHO, 1 g·kg⁻¹·day⁻¹ fat; HCHO) or an isocaloric high-fat diet (2.6 g·kg⁻¹·day⁻¹ CHO, 4.6 g·kg⁻¹·day⁻¹ fat; fat-adapt) for 6 days. On day 8, subjects consumed a high-CHO diet and rested. On day 9, subjects consumed a preexercise meal and then cycled for 4 h at 65% peak O₂ uptake, followed by a 1-h time trial (TT). Compared with baseline, 6 days of fat-adapt reduced respiratory exchange ratio (RER) with cycling at 65% peak O₂ uptake [0.78 ± 0.01 (SE) vs. 0.85 ± 0.02; P < 0.05]. However, RER was restored by 1 day of high-CHO diet, preexercise meal, and CHO ingestion (0.88 ± 0.01; P > 0.05); RER was higher after HCHO than fat-adapt (0.85 ± 0.01, 0.89 ± 0.01, and 0.93 ± 0.01 for days 2, 8, and 9, respectively; P < 0.05). Fat oxidation during the 4-h ride was greater (171 ± 32 vs. 119 ± 38 g; P < 0.05) and CHO oxidation lower (597 ± 41 vs. 719 ± 46 g; P < 0.05) after fat-adapt. Power output was 11% higher during the TT after fat-adapt than after HCHO (312 ± 15 vs. 279 ± 20 W; P = 0.11). In conclusion, compared with a high-CHO diet, fat oxidation during exercise increased after fat-adapt and remained elevated above baseline even after 1 day of a high-CHO diet and increased CHO availability. However, this study failed to detect a significant benefit of fat adaptation to performance of a 1-h TT undertaken after 4 h of cycling.

Fat adaptation and prolonged exercise performance

To the Editor: Very belatedly, I have reread more thoroughly the important and carefully conducted study of Carey et al. (2). This appears to be the first to have prudently evaluated the effects of short-term adaptation to a high-fat diet on performance during an exercise bout that was sufficiently prolonged.

If, as the authors stress, acute adaptation to a high-fat diet is to enhance exercise performance, then such adaptation must logically occur when exercise is of a sufficient duration to induce near-total muscle glycogen depletion. This will likely occur in more prolonged exercise, especially exercise lasting ≥5 h, which is the duration evaluated in this trial.

Although there is no question that the authors have collected their data with their usual meticulous attention to detail, my concerns relate purely to the logic of their conclusions.

Thus, in the last sentence on page 120, the authors state that “on average, subjects rode the [time trial] at a power output that was 11% higher after fat adaptation, and, although this performance enhancement failed to reach statistical significance, it represented an ~4% improvement, which would certainly be worthwhile and meaningful for an endurance athlete (19).” Indeed a 4% improvement during the final 42 km of an ultra triathlon would represent a time improvement of 6 min 36 s on a time of 2 h 40 min, a substantial effect.

Yet, in their conclusion on page 121, the authors seem to forget this pitch because they now conclude that “this study failed to detect a statistically significant benefit [of a high-fat diet and carbohydrate restoration] to performance of a 1-h [time trial] undertaken after 4 h of continuous cycling.”

The nub of the statistical problem appears in Fig. 5, which seems to show that the performance of five of the seven subjects improved after the high-fat diet. Surely, a more logical conclusion should have been that the sample size may have been just too small to detect what appears to be a potentially very large ergogenic effect of a high-fat diet, i.e., that the sample size was too small to exclude a type II error.

Perhaps the authors should be invited to calculate the sample size necessary to exclude a false negative type II finding according to their extensive review article published on this exact topic (3).

Given the unchallenged dominance of a prevailing dogma, which is enthusiastically embraced by a variety of commercial interests and holds that only a high-carbohydrate diet can optimize endurance performance (1), it is perhaps essential that studies that appear to disprove this dogma will need to be of perfect design.

REFERENCES


Timothy Noakes
Discovery Health Chair of Exercise and Sports Science MRC/UCT Research Unit for Exercise Science and Sports Medicine
Department of Human Biology
University of Cape Town, Sports Science Institute of South Africa
Newlands 7700, South Africa
E-mail: tdnoakes@sports.uct.ac.za

REPLY

To the Editor: We wish to thank Professor Noakes for his interest in the results of our study (4) and to the Editor for the opportunity to respond. It is indeed curious that our fat adaptation/carbohydrate restoration strategy, which has consistently been shown to spare muscle glycogen utilization during prolonged submaximal exercise (1, 4), does not appear to provide a clear benefit to the performance of a subsequent cycling bout. In a recent review (2), we speculated on a number of potential factors that may explain this discordance. These include (but are not limited to) 1) other strategies incorporated in our study protocol that maintain high levels of carbohydrate availability (i.e., preevent carbohydrate meal, carbohydrate feedings during the exercise bout) and allow the athlete to perform optimally; 2) the “individual response” to fat adaptation; 3) the fact that fat adaptation fails to provide the brain and central nervous system with adequate signaling of the favorable metabolic changes in the muscle, thereby failing to elicit an improved (optimal) pacing strategy; and 4) the possibility that we are unable to detect changes in performance that would be worthwhile for a competitive athlete due to a type II error or underpowering of the study design.

It is to this last factor that Professor Noakes makes comment. As coauthors of an invited review on detecting performance changes relevant to competitive athletes (5), we are
aware of the potential shortcoming and limitations of traditional laboratory-based research. In the study of Carey et al. (4), we not only commented on the “statistical significance” of the observed performance outcomes but also discussed the relative performance changes in the context of a road cycling race and the likely range of results that could be expected in a similar population of well-trained athletes (i.e., the 95% confidence intervals). Both interpretations of the study are correct and were indeed requested by the reviewers of that original study (4).

We agree that, on the basis of the results of Carey et al. (4), a coach or an athlete involved in an ultraendurance competition could not afford to dismiss our dietary periodization strategy. Indeed, so concerned were we at the possibility of a type II error that we embarked on another separate investigation using an identical exercise and diet protocol to that described in our previous study (4). We can report that, to date, six subjects with the same physiological characteristics as our first study (4) have completed the trials. Our interim results reveal the following effects on 1-h time trial performance: control (high carbohydrate) 41.92 ± 1.46 km, 275 ± 25 W; fat adaptation 41.94 ± 1.41 km, 276 ± 23 W (P = 0.98, performance difference = 0.02 km or 0.1%). To determine the effect of fat-adaptation strategies on endurance/ultraendurance performance, we plan to add another 3–4 subjects to the total sample to provide the possibility of pooling data from 16 subjects spread over the two studies, thus considerably adding to the statistical power. Although it is premature to predict the final outcome, the new data are not supportive of a type II error in our original study (4).

There is overwhelming evidence that a range of strategies that enhance carbohydrate availability are often associated with an enhancement of endurance and performance of prolonged exercise. We suspect that the apparent difficulty of finding situations in which dietary strategies that enhance fat availability and utilization provide clear-cut benefits is underpinned by issues far more complex than Professor Noake’s assertion of “an unchallenged dominance of a prevailing dogma” and the influence of commercial interests. It is to the best interest of all athletes, coaches, and the sports scientists with whom they work to explore the variety of dietary strategies that could work singly or in combination to enhance training and competition performance. We do not wish to be blinkered into thinking that there is a single solution to the dietary preparation of all athletes or all sports events, or that this issue is as simple as a “fat vs. carbohydrate” debate.

REFERENCES


Louise M. Burke
Department of Sport Nutrition
Australian Institute of Sport
Belconnen, Australian Capital Territory 2616
Australia

Andrew L. Carey
John A. Hawley
Exercise Metabolism Group
School of Medical Sciences
RMIT University
Bundoora 3083, Victoria, Australia