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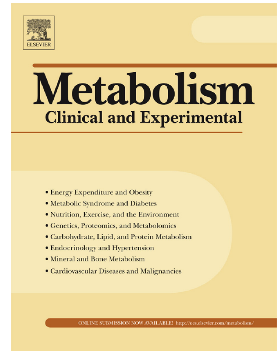

Keto-adaptation enhances exercise performance and body composition responses to training in endurance athletes

Fionn T. McSwiney, Bruce Wardrop, Parker N. Hyde, Richard A. Lafountain, Jeff S. Volek, Lorna Doyle

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Title. Keto-adaptation enhances exercise performance and body composition responses to training in endurance athletes.

Authors. Fionn T. McSwiney[a], Bruce Wardrop[a], Parker N. Hyde[b], Richard A. Lafountain[b], Jeff S. Volek[b], Lorna Doyle[a]

[a]Department of Sport, and Exercise Science, Waterford Institute of Technology, Waterford, Ireland

[b]Kinesiology Program, Department of Human Sciences, The Ohio State University, Columbus, OH, USA

Corresponding author at: Department of Sport, and Exercise Science, Waterford Institute of Technology, Waterford, Ireland.

E-mail address: lmdoyle@wit.ie (L. Doyle).

ABSTRACT

Background. Low-carbohydrate diets have recently grown in popularity among endurance athletes, yet little is known about the long-term (>4 wk) performance implications of consuming a low-carbohydrate high fat ketogenic diet (LCKD) in well-trained athletes.

Methods. Twenty male endurance-trained athletes (age 33 ± 11y, body mass 80 ± 11kg; BMI 24.7 ± 3.1 kg/m^2) who habitually consumed a carbohydrate-based diet, self-selected into a high-carbohydrate (HC) group (*n* = 11, %carbohydrate:protein:fat = 65:14:20), or a LCKD group (*n* = 9, 6:17:77). Both groups performed the same training intervention (endurance, strength and high intensity interval training (HIIT)). Prior to and following successful completion of 12-weeks of diet and training, participants had their body composition assessed, and completed a 100km time trial (TT), six second (SS) sprint, and a critical power test (CPT). During post-intervention testing the HC group consumed 30–60g/h carbohydrate, whereas the LCKD group consumed water, and electrolytes.

Results.

The LCKD group experienced a significantly greater decrease in body mass (HC -0.8 kg, LCKD -5.9 kg; *P* = 0.006, effect size (ES): 0.338) and percentage body fat percentage (HC -0.7%, LCKD -5.2%; P = 0.008, ES: 0.346). Fasting serum beta-hydroxybutyrate (βHB) significantly increased from 0.1 at baseline to 0.5 mmol/L in the LCKD group (*P* = 0.011, ES: 0.403) in week 12. There was no significant change in performance of the 100 km TT between groups (HC -1.13 min.sec, LCKD -4.07 min.sec, *P* = 0.057, ES: 0.196). SS sprint peak power increased by 0.8 watts per kilogram bodyweight (w/kg) in the

LCKD group, versus a -0.1 w/kg reduction in the HC group (*P* = 0.025, ES: 0.263). CPT peak power decreased by -0.7w/kg in the HC group, and increased by 1.4 w/kg in the LCKD group (*P* = 0.047, ES: 0.212). Fat oxidation in the LCKD group was significantly greater throughout the 100km TT.

Conclusions. Compared to a HC comparison group, a 12-week period of keto-adaptation and exercise training, enhanced body composition, fat oxidation during exercise, and specific measures of performance relevant to competitive endurance athletes.

Keywords: ketogenic, high-carbohydrate, fat, endurance, performance, body composition

Dear Editor,

We appreciate the opportunity to address concerns raised by Mr. Pickering.

His first comment was that the differences in body composition responses between groups were no longer statistically significant after accounting for baseline differences in body fat, “a finding buried in text” as he suggested. Perhaps we did bury it, because we scoured every word of our paper and could not find it. We acknowledged in the paper there were significant differences in body composition between groups at baseline. We clearly state in the statistical section that body fat was used as a covariate. We clearly state in the results section that the greater loss of body fat remained significant after using this covariate. Moreover, the accusation is misplaced because loss of body fat and improved body composition in the LCKD group was an expected positive outcome, one based on a robust body of literature (1,2).

His second point that performance decreased in the LCKD group when accounting for weight loss is also off base. Measures of absolute power were not different between groups (see Supplemental Table 1). The power outputs were presented in the manuscript relative to body mass because relative power is highly correlated with cycling performance (3-5). In the real World, competitive cyclists are not penalized if they lose body fat while maintaining lean muscle, which is what happened in the LCKD group. Perhaps Mr. Pickering thinks Tour de France champion Chris Froome should be handicapped with a 20-pound sack of potatoes because he lost that much weight on a low-carbohydrate diet (6). The ability of a low-carbohydrate diet to promote an improved power to weight ratio is an asset, not a liability.

We allowed participants to self-select diet group, but did not ascertain specific reasons for their choice. Our rationale for not performing a randomized study was that in the real-World, athletes have a choice what foods they want to eat. In a randomized trial, potential subjects need to be informed about both diet options. If we accurately presented the two eating patterns and potential benefits, this introduces a significant enrolment bias. Further, since the athletes were often interacting and training together, any perceived benefits for one diet would ‘pollute’ adherence to the other diet.

Regarding the question of energy intake and training records, diet logs indicated no significant differences in caloric intake or number of training sessions between groups, intensity of training volume over the intervention was not quantified. It is well known that diet records are notoriously inaccurate (7), so we caution reading too much into the numerical non-significant difference reported between groups.

The concept that athletes could perform well on a ketogenic diet is not new (8), but it has taken more than 3 decades for that spark to be ignited (9-11). While we disagree that our paper was misleading, we do appreciate that Mr. Pickering has given us the opportunity to shed additional light on this topic that has lived in the shadows for too long.

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