A Whey-Supplemented, High-Protein Diet Versus a High-Carbohydrate Diet: Effects on Endurance Cycling Performance

Paul W. Macdermid and Stephen R. Stannard

This study compared a training diet recommended for endurance athletes (H-CHO) with an isoenergetic high protein (whey supplemented), moderate carbohydrate (H-Pro) diet on endurance cycling performance. Over two separate 7-d periods subjects \((n = 7)\) ingested either H-CHO \((7.9 \pm 1.9 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}\) carbohydrate; \(1.2 \pm 0.3 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}\) fat; \(1.3 \pm 0.4 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}\) protein) or H-Pro \((4.9 \pm 1.8 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}\); \(1.3 \pm 0.3 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}\); \(3.3 \pm 0.4 \text{ g} \cdot \text{kg}^{-1} \cdot \text{d}^{-1}\)) diet in a randomized, balanced order. On day 8 subjects cycled (self-paced) for a body weight dependent \((60 \text{ kJ/bm})\) amount of work. No differences occurred between energy intake \((P = 0.422)\) or fat intake \((P = 0.390)\) during the two dietary conditions. Performance was significantly \((P = 0.010)\) impaired following H-Pro \((153 \pm 36)\) compared with H-CHO \((127 \pm 34)\) min. No differences between treatments were observed for physiological measures taken during the performance trials. These results indicate an ergolytic effect of a 7-d high protein diet on self-paced endurance cycling performance.

Key Words: self-paced, athletic dietary guidelines, low carbohydrate

The effects of dietary carbohydrate (CHO) manipulations on exercise performance have been widely studied (7, 10, 23). Improvements in endurance (18, 28) and more recently intermittent exercise performance (4) following diets with CHO intakes of 7 to 10 g · kg⁻¹ · d⁻¹, have been shown.

The health sector has embraced high protein diets, while many sports coaches and sports specific magazines report and endorse the benefits of high protein intakes by athletes (2). Irrespective of the cause, the diets of many sports participants contain protein intakes of ~ 3 g · kg⁻¹ · d⁻¹ without purposeful explanation and understanding of performance effects.

Little scientific information exists concerning the purported ergogenic effects of such high protein intakes on endurance performance with the only other study (16) relating high protein diets to endurance performance highlighting its limitations. In this study, subjects lost body mass, and time to exhaustion at 80% \(\text{VO}_2\text{max}\)
significantly decreased while consuming a diet of macronutrient proportions 36:27:37 compared with 54:22:24 for CHO:Fat:Protein respectively. However, there was a significant difference in energy intake between the two diets. The amount of training performed during the interventions was not controlled, and the CHO intake (g/d) in both diets was below that recommended for endurance athletes (11). Numerous studies (19, 20, 24, 25) have compared the effects of moderate CHO intakes (~5 g · kg⁻¹ · d⁻¹) versus H-CHO intakes (7–10 g · kg⁻¹ · d⁻¹) on performance during periods of training. Findings were equivocal as no association between CHO intake and muscle glycogen depletion and performance was found (19,24), while others (25) showed H-CHO intake increased muscle glycogen content and performance. However, dietary intake deficits brought about through CHO manipulation were accommodated through increases in fat intake rather than protein intake.

Clearly there is a paucity of well-controlled studies assessing the effect of high protein diets on endurance performance when energy intake is controlled. Therefore, the aim of this study was to compare the influence of an isoenergetic, constant training load, high protein (whey-supplemented); Mod-CHO diet (H-Pro) with a diet based on guidelines for endurance athletes (H-CHO) (2), on endurance cycling performance. A secondary aim was to measure the effects of the interventions on metabolism and the protein contribution to whole body metabolism during rest and endurance cycling.

**Methods**

**Subjects**

Seven competitive endurance trained cyclists participated in the study. All participants were fully informed about the procedures, time demands, and risks associated with participation in the study, signed a consent form and completed a pre-test questionnaire. The study was approved by the Manawatu/Wanganui (NZ) Human Ethics Committee.

On the initial visit to the laboratory subjects supplied a completed 3 d weighed food record, analyzed for an average day (Diet Cruncher, Way Down South Software, Dunedin, NZ) along with a 1 wk training record in order to compute the typical weekly training load (TRIMP) (5). Subject’s height (cm) and weight (kg) were measured prior to performing a ramp test to exhaustion (22) using a cycle ergometer (Monark 893E). During the test, expired gas data was collected continuously using an automated system (Parvomedics Truemax 2400) enabling the calculation of VO₂peak (absolute and relative), ventilatory threshold (VT), and respiratory compensation point (RCP), all of which have been used in the past as reliable indicators of endurance performance (22). VT was defined as the point at which the ventilatory equivalent for O₂ (VE:VO₂) and partial pressure of O₂ (PETO₂) started to increase with no subsequent increase in ventilatory equivalent for CO₂ (VE:VCO₂). RCP was determined as the point where the VE:VO₂ and VE:VCO₂ increased at the same point with a subsequent decrease in PₐCO₂ (22). Subject characteristics are shown in Table 1. Following a 30 min recovery period a familiarization period was performed (50% of the performance test) with the main aim of enabling subjects to familiarize themselves with the Kingcycle (EDS Portaprompt...
Effects of High Protein vs. High Carbohydrate Diet

Ltd., High Wycombe, UK) and to gauge the likely duration of the performance trial. The Kingcycle uses the subject’s own bicycle with front fork attached to the ergometer while the rear wheel drives a roller connected to a centrifuged impellar. This provides a rolling resistance similar to that on the road through pre-test calibration and tire (Specialized Armadillo, turbo) pressure kept at 8.0 BAR for all subjects. Power output (W) of the Kingcycle is calculated (Equation 1) through computer software (EDS Portaprompt Ltd., High Wycombe, UK).

\[
W = 0.000136 RPS^3 + 1.09 RPS
\]

Where, \(RPS\) = revolutions per second measured by a photo-optic sensor

General Design

Using a repeated measures design, the two nutritional strategies were blinded (achieved through provision of flavored liquid supplements) and performed in a balanced order with a 10 d minimum to 14 d maximum washout period between trials (16, 20). The specific aim of each intervention was to achieve either a diet with a protein intake of 1.2–1.4 g · kg\(^{-1}\) · d\(^{-1}\) and a CHO intake of 7–10 g · kg\(^{-1}\) · d\(^{-1}\) (H-CHO) or a diet with a protein intake of 3–4 g · kg\(^{-1}\) · d\(^{-1}\) and a CHO intake of ≤ 5 g · kg\(^{-1}\) · d\(^{-1}\) (H-Pro) while keeping fat intake and total energy intake constant. A 7 d weighed food record was kept throughout and analyzed for macronutrient and water content (Diet Cruncher). All subjects were asked to maintain normal weekly training volumes leading up to each trial, recorded using TRIMP (5), provide written comments regarding the interventions, and refrain from strenuous training and the consumption of alcohol 24 h prior to each performance trial.

On the day of the experiment, subjects reported to the laboratory after an overnight fast (12 h) and were instructed to drink 500 mL of water 2 h prior to the

### Table 1  Subject Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>33.6 (5.0)</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>68.6 (4.7)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.4 (7.3)</td>
</tr>
<tr>
<td>(VO_2)peak (L/min)</td>
<td>4.51 (0.44)</td>
</tr>
<tr>
<td>(W_{\text{peak}}) (W)</td>
<td>398 (27)</td>
</tr>
<tr>
<td>(W) @ VT</td>
<td>209 (34)</td>
</tr>
<tr>
<td>(W) @ RCP</td>
<td>302 (33)</td>
</tr>
<tr>
<td>Average weekly training load (TRIMP)</td>
<td>774 (345)</td>
</tr>
</tbody>
</table>

*Note. Values are means ± standard deviation. \(VO_2\)peak, highest recorded oxygen consumption in a 15 s period; \(W_{\text{peak}}\), highest recorded power output (W) during the ramp test; VT, ventilatory threshold; RCP, respiratory compensation point; TRIMP, training impulse (5).*
performance test to ensure adequate hydration status (2). Two sets of measures were then taken in the fasted state to assess the effects of the dietary strategies on a) resting metabolism and cardiovascular adaptations, and b) self-paced endurance performance.

**Resting Samples.** On arrival at the laboratory subjects were weighed in order to determine the workload of the performance test (Equation 2). Subjects then relaxed for 5 min in a seated position where heart rate was monitored using short-range radio telemetry (Polar Accurex plus, Polar Electro, Kempele, Finland) and blood pressure (ADC Sphygmanometer & ADSCOPE 641) was measured. This was then followed by a further 10-min of rest where only the final 5 min of expired air collection (ParvoMedics Truemax 2400, Sandy, UT (6)) was recorded in order to ensure a true measure of resting metabolic rate. A capillary blood sample (25 μl) taken immediately after the resting period was measured for lactate (YSI 1500, YSI Life Sciences, Inc., Yellow Springs, OH) and glucose (MediSense2, Doncaster, Australia).

**Performance Test.** Following calibration of the Kingcycle ergometer, a standardized warm-up (5 min at both 30% and 50% of W_{max}) was performed before embarking on a self-paced performance time trial (TT). The formula is body weight (kg) dependent, based on the cyclist expending 60 kJ/min during competitive cycling and takes into account the Kingcycle’s overestimation of energy expenditure when compared with that of an automated metabolic measurement system (ParvoMedics Truemax 2400) at set power outputs (W). The performance workload can be calculated (Equation 2).

Equation 2:

\[
\text{Performance trial work (kcal) = } [(bw \times (60/4.184)) – 25.45]/0.54
\]

Where, \(bw\) equals body weight (kg); \(60/4.184\) equals the energy expenditure per minute converted to kcal for compatibility with the Kingcycle. This equates to 30 to 35 km/h on flat terrain, no wind, in seated position (17).

During each trial, water was made available ad libitum, the volume was recorded and combined with pre- and post TT body weight measures for calculation of fluid loss.

**Performance Measures**

Every 10% of the total workload (kcal), time (min:sec) and mean power output (W) was recorded. The main performance measure was the total time (min:sec) taken to complete the predetermined workload.

**Physiological Measures**

Heart rate was recorded at 5 s intervals throughout the duration of the test and averaged for each 10% of the work period. Subjects were also asked for a rating of their perceived exertion (RPE) (9) at each 10% of the work period.

Expired respiratory gas samples (Parvo Medics TrueMax 2400) were taken enabling calculations for VO_{2} (mL·kg^{-1}·min^{-1}) and respiratory gas exchange ratio (RER) every 10% of the work period.
Capillary blood samples (25 μl) collected from the finger every 10% of the work period were measured immediately for lactate (YSI 1500) and glucose (MediSense2).

A blood sample (5 mL) was collected from a vein in the antecubital area pre-exercise and immediately post-exercise. Samples were centrifuged and the plasma was stored at −20 °C and later analyzed for urea (Cobas Fara II, Hoffman La Roche, Basel, Switzerland). Urea concentration was measured via a coupled urease/glutamate dehydrogenase assay (25) using a urea diagnostic kit (Roche Diagnostics NZ Ltd., Auckland, NZ).

Pre-(24 h) urine samples were collected into sterile 3 L urine collection containers and kept at < 5 °C by the subjects until the morning of the trial. Post performance trial urine was collected directly into a sterile measuring cylinder. Both 24 h and post performance trial collections were measured for total volume, and small aliquots (10 mL) were stored at −20 °C and later analyzed for urea (as resting blood sample measurement).

Protein contribution to energy metabolism is represented by N excretion. At rest (Equation 3) this was estimated from 24 h urinary excretion during the final 24 h of dietary intervention.

Equation 3:

\[
\text{24 h N excretion at rest (g)} = \text{Vol. urine} \times \text{conc. urea} \times 28/1000
\]

With urine Vol. (L), urea conc. (mmol/L); and where 28 equals the molecular weight of N in urea.

The sum of urinary urea excretion during exercise plus urea accumulation in the blood was used to calculate protein contribution to metabolism during exercise (Equation 4). Each subject was asked to void just prior to exercise, then void again immediately after exercise into a receptacle from which the volume was measured and a representative aliquot taken and stored. The urea concentration was measured (26), and multiplied by the measured volume to give urinary urea excretion (Equation 3).

Urea accumulation in the blood during exercise was calculated from the increase in plasma urea concentration over the exercise period (adjusted for changes in hematocrit) times plasma volume (Equation 5). Plasma volume was estimated from scientific tables (12).

Equation 4:

\[
\text{Protein N utilization during exercise} = \text{N in urine (g) + N accumulation in blood (g)}
\]

Equation 5:

\[
\text{N accumulation in plasma during exercise (g)} = \left[(\text{plasma urea pre-exercise (mmol/L)} \times (\text{BW} \times 0.071) \times (100-\text{Hct pre-exercise})) - (\text{plasma urea post-exercise (mmol/L)} \times (\text{BW} \times 0.071) \times (100-\text{Hct post-exercise})\right] \times 28/1000
\]

Where, BW = body weight (kg); 0.071 = blood volume (L) per kg BW in a human male adult (12); Hct = hematocrit (%); 28 = molecular weight of N₂ in urea.
Mean values of \( \text{VO}_2 \) and \( \text{VCO}_2 \) for the total duration of each trial (the sum of the mean for all 10% workload periods) were used in conjunction with total N accumulation during exercise and the TT time to estimate the rate of substrate utilization using the Equations 6 a, b, and c. (13).

Equation 6:

a) \( \text{CHO (g/min)} = (4.55 \text{ VCO}_2) - (3.21 \text{ VO}_2) - (2.87n) \)

b) \( \text{Fat (g/min)} = (1.67 \text{ VO}_2) - (1.67 \text{ VCO}_2) - (1.92n) \)

c) \( \text{Protein (g/min)} = (n6.25) / t \)

With \( \text{VO}_2 \) and \( \text{VCO}_2 \) in L/min, where \( n \) is the protein N accumulation during exercise in g (see equation 3), 6.25 = amount protein required to excrete 1g N, and \( t \) is total duration (minutes) for the performance trial.

Statistical Analysis

Data collected during the two intervention periods (dietary energy and macronutrient intake, and TRIMP) were compared by paired Student’s t-tests. Dependent variables collected during exercise and diet were compared between dietary conditions for interactions via two-way repeated measures analysis of variance (diet × time). Significance level for statistical analysis was set at the \( P < 0.05 \) level.

Results

The intention that there was no difference between the total weekly energy intake (kcal) was achieved \( (P = 0.390) \). Energy intakes were 23,588 ± 4677 kcal and 21,348 ± 5342 kcal for the H-CHO and H-Pro interventions, respectively. Differences \( (P < 0.001 \) and \( P = 0.001) \) were found between macronutrient intakes between interventions for CHO \( (7.9 ± 1.9 \text{ g · kg}^{-1} \cdot \text{d}^{-1} \) and \( 5.9 ± 1.9 \text{ g · kg}^{-1} \cdot \text{d}^{-1} \)) and protein \( (1.3 ± 0.4 \text{ g · kg}^{-1} \cdot \text{d}^{-1} \) and \( 3.3 ± 0.4 \text{ g · kg}^{-1} \cdot \text{d}^{-1} \)) while fat remained unchanged \( (1.2 ± 0.3 \text{ g · kg}^{-1} \cdot \text{d}^{-1} \) and \( 1.3 ± 0.4 \text{ g · kg}^{-1} \cdot \text{d}^{-1} \)) for the H-CHO and H-Pro interventions, respectively.

Training Load

Training load (TRIMP) during the H-CHO \( (982 ± 323) \) and H-Pro \( (715 ± 366) \) interventions did not differ significantly \( (P = 0.051) \), though there was a tendency for a reduced training load during the week of the H-Pro diet.

Resting Measures

There was no effect of dietary condition on body mass \( (67.6 ± 5.0 \text{ and } 67.8 ± 35.1 \text{ kg},) \), blood pressure \( (124/80 \text{ and } 121/77 \text{ mmHg}) \), blood glucose concentration \( (4.6 ± 0.5 \text{ and } 4.6 ± 0.95 \text{ mmol/L}) \), blood lactate concentration \( (1.56 ± 0.59 \text{ and } 1.19 ± 0.3 \text{ mmol/L}) \), hematocrit \( (46 ± 4 \text{ and } 47 ± 4\%) \) and resting metabolic rate \( (1.62 ± 0.28 \text{ and } 1.43 ± 0.12 \text{ kcal/min}) \) for the H-CHO and H-Pro diets,
respectively. However, RER (0.90 ± 0.11 and 0.85 ± 0.09) and heart rate (58 ± 13 and 53 ± 10 bpm) were significantly lower ($P = 0.036$ and $P = 0.044$), following 7 d of the H-Pro diet.

**Time Trial Performance**

The time taken to complete the self-paced TT was significantly ($P = 0.01$) increased (Figure 1) during the H-Pro condition when compared to the H-CHO trial (126.91 ± 34.16 vs. 153 ± 35.92 min). Accordingly, average power output was significantly lower during the H-Pro trials (293 ± 64 and 197 ± 55 W), $P = 0.013$ (Figure 1). Repeated-measures ANOVA analysis showed no interaction (diet × time) for either performance times ($P = 0.107$) or power outputs (Figure 2, $P = 0.300$) for each 10% workload.

Neither fluid intake during exercise or total mass loss following exercise differed ($P = 0.0751$ and $P = 0.182$) between dietary conditions.

**Physiological Measures**

Repeated-measures ANOVA analysis revealed no interaction (diet × time) for heart rate during the TT ($P = 0.704$). However, there was a main effect of diet ($P = 0.005$) on heart rate with average values for the total work time (148 ± 14 bpm H-CHO and 138 ± 12 bpm H-Pro).

There was no interaction (diet × time) ($P = 0.626$) and no main effect of dietary interventions ($P = 0.947$) on RPE. As expected in endurance based performance trials, repeated-measures ANOVA analysis did show a main effect of time ($P < 0.01$) with RPE increasing in a linear fashion.

Hematocrit values did not differ ($P = 0.329$) between diets post exercise. Blood lactate (mmol/L) response showed no diet × time interaction ($P = 0.685$), no main effect of diet ($P = 0.087$), nor a main effect of time ($P = 0.123$).

There was no diet × time interaction ($P = 0.482$) or main effect of diet ($P = 0.738$) on blood glucose (mmol/L), however a main effect of time was apparent ($P = 0.000$) during both trials (Figure 3).

**Respiratory Gas Analysis**

There was no interaction between diet and time ($P = 0.310$) and no main effect of dietary intervention ($P = 0.054$) or time ($P = 0.152$) on VO$_2$ (mL · kg$^{-1}$ · min$^{-1}$).

RER values showed no interaction (diet × time) ($P = 0.567$) and did not change significantly with dietary intervention ($P = 0.147$) or over time during the performance trial ($P = 0.297$).

In addition, calculated substrate oxidation rates for the whole performance trial showed no significant changes in substrate utilization. CHO oxidation accounted for 81 ± 17 and 77 ± 18%, fat oxidation accounted for 17 ± 16 and 20 ± 18%, and protein oxidation accounted for 3 ± 3 and 3 ± 2% of total energy expenditure, in the H-CHO and H-Pro interventions respectively (Figure 4). This is replicated through finding no differences ($P = 0.538$) between interventions and N$_2$ accumulation post performance trial (0.0306 ± 0.0277 and 0.0547 ± 0.0935 g for the H-CHO and H-Protein diets, respectively).
Discussion

Although macronutrient composition of diet and the relative effects on performance have been studied for decades, few studies have attempted to elucidate and quantify the effects of the high quantities of protein consumed by many sports enthusiasts as a result of food preferences, supplementation, and/or media influences on endurance performance. A major finding of this investigation was the significant difference between pure performance measures and diet, including lower power outputs (W) culminating in a mean difference of total performance time (+26.1 min) following a 7 d H-Pro diet.
Figure 3 — Blood glucose concentrations (standard deviation) during the performance trials. 
## main effect of time ($P < 0.01$)

Figure 4 — Mean ($n = 6$) substrate oxidation rates following a 7-d H-CHO or 7-d H-Pro diet for the total work period
The analysis of mean total energy intake and macronutrient intake (Figure 1) diminishes an energy intake deficit between diets as the likely cause for divergence in performance. It also enables comparisons of current recommendations for endurance athletes (2, 21, 27) with protein intakes consumed by many sports enthusiasts. However, there are limitations in prescribing dietary recommendations to subjects and relying on them to meet the requirements while going about their everyday tasks. As a result, we collected weighed dietary records on a daily basis for the first 3 d to make sure subjects were meeting their targets and to adjust intakes accordingly for following days. It should be acknowledged that although the mean energy intake values suggest no significant difference, in reality this is very unlikely due to natural week-by-week variability in energy intake.

The main effect of diet on performance resulted in a lower mean power output (W) during the H-Pro trial (Figure 1). Lower power outputs at each 10% period of total workload (Figure 2), were found in all subjects. However, the lack of any interaction between dietary intervention and time during the performance trials suggests subjects' performance was impaired from the outset during the H-Pro intervention.

The ergolytic effect of the H-Pro diet on cycle performance of this duration cannot be questioned based on the attained results. These findings differ with those of other studies (20, 24) that compared H-CHO with Mod-CHO diets during periods of intense training and found no dietary effect on swim performance (20) or running and cycling performance (24). However, one study (25) did show that although a Mod-CHO diet did not impair rowing performance, H-CHO diet did increase mean power output by 10.7%. It is also important to highlight that although these studies used isoenergetic dietary interventions, protein intake was not manipulated and any changes in CHO intake were accommodated for by changes in fat intake. In contrast, the present study examined the effects of a Mod-CHO, H-Protein diet with the recommended dietary macronutrient intake of endurance athletes. The durations of the performance trials where data is given in the aforementioned studies (20, 25) were also shorter and of a higher intensity than used in this study.

Muscle glycogen content was not measured during this study, though others (7, 18, 28) have shown the importance of maintaining muscle glycogen stores for endurance training and performance lasting > 90 min. During the H-Pro trial, our subjects may have at best maintained normal muscle glycogen levels, compared to increases during the H-CHO trial. The potential glycogen deficit in H-Pro compared with the H-CHO would have been compounded by the repetitive effect of almost normal training loads. During the present study, however, power output was significantly lower from the start of exercise, with no diet × time interaction. This suggests that exercise induced glycogen depletion did not limit performance and some other factor which decreased power output from the start of the exercise test appears to be the limiting factor. Others (25) have also suggested that a 7-d period may not be sufficient to enable potential chronic adaptations to take place. A longer intervention period may have led to a greater adaptation to the diet (H-Pro) and a potential different outcome in performance.

The results of this study showed no significant difference between blood glucose concentrations and diets at rest and during the exercise period. The blood
glucose concentrations for both trials (Figure 3) reflect the debilitating effect of prolonged exercise, with a number of subjects showing symptoms of hypoglycemia (blood glucose < 3.0 mmol/L).

A common adaptation of the body in a CHO crisis is to increase its utilization of fat (3, 8, 15, 18). Increases in fat oxidation estimated from RER are typically accompanied by an increase in VO$_2$ and a resultant decreased economy (19). However, in the present study estimated fat oxidation through use of RER data showed no statistical differences, while VO$_2$ remained similar and economy shown as (W/mL of O$_2$ · kg$^{-1}$ · min$^{-1}$) decreased during the H-Pro trial (data not shown). Again this study (19) kept energy intake similar via the manipulation of fat rather than protein intake which may affect substrate utilization dynamics. It is also worth mentioning that sampling data during self-paced trials potentially could lead to spurious results in that subjects can be motivated by the periods of gas collection and adapt the intensity of effort accordingly.

A greater pre-exercise glycogen status results in greater rates of muscle glycogenolysis and higher blood lactate values (7, 8, 14). Blood lactate measures along with heart rate and VO$_2$ have also been used to gauge the intensity of exercise performed by athletes in the laboratory setting. Besides the metabolic implications, greater individual lactate values are associated with increased performance, an outcome exemplified within the results of this study. Thus, the implications would suggest an increase, although not statistically significant, of intensity yet measures of perceived exertion between trials were almost identical, indicating the consistency of effort applied by subjects.

Written feedback regarding the H-Pro trial included a satiating effect, feelings of general fatigue, headaches, gastrointestinal discomfort, and general feelings of unwellness particularly in the early stages of the 7-d period. In many cases, subjects found their normal training duration was curtailed for the same intensity or training intensity was reduced as they would ride at lower speeds over the same distances. These symptoms are synonymous with overreaching and previously shown in CHO deficient diets (1).

In summary, the findings of this study have shown that a 7-d H-Pro diet had a significant overall ergolytic effect on performance when compared to the diet recommended for an endurance cyclist. Metabolic/physiological measurements mirror performance data in that the results implicated greater intensity of effort during the H-CHO trial but this was not associated with differences in macronutrient utilization.

References


