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**CARBOHYDRATE SUPPLEMENTATION FAILS TO IMPROVE THE SPRINT PERFORMANCE OF FEMALE CYCLISTS**

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**ABSTRACT**

**Carbohydrate Supplementation Fails to Improve the Sprint Performance of Female Cyclists.** ANTHONY T. JARVIS, SCOTT D. FELIX, STACY SIMS, MARGARET T. JONES, MARY ANNE COUGHLIN and SAMUEL A. HEADLEY *JEP*online 1999, 2(2):16-23. This study was designed to examine the effect of a 7% carbohydrate electrolyte beverage (CE) on the sprint performance of trained female cyclists immediately following 50 min of cycle ergometry at 80%  $\dot{V}O_2$ max. The Wingate Anaerobic Power Test (WAT) was used to measure peak power, mean power, minimum power, and rate of fatigue. No significant ( $p > .05$ ) differences were found between the CE and placebo (PL) treatments for any WAT indices. Blood glucose was found to be significantly higher ( $p < .05$ ) toward the end of the time trial for the CE group than for the PL group. RPE increased more dramatically from baseline for the PL group than for the CE group ( $p < .05$ ). The results suggest that high intensity exercise performance of female cyclists is not improved with the consumption of a CE beverage during exercise despite a reduced perception of effort.

**Key words:** Wingate, Anaerobic, Carbohydrate-electrolyte, Females

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**INTRODUCTION**

At relatively high workloads, the depletion of intramuscular glycogen limits prolonged exercise capacity (1). The elevation of muscle and liver glycogen stores to approximately twice normal levels has been shown to improve endurance performance (2). When liver and muscle glycogen levels have been elevated, the ingestion of

carbohydrate does little to improve performance (3). Also, when liver glycogen levels are low or depleted, as in the case of an overnight fast (4), performance may be negatively impacted. The resultant decline in plasma glucose contributes to fatigue during prolonged exercise by limiting carbohydrate oxidation (5).

In the fasted condition, where glycogen levels are

very low or depleted, the use of an exogenous carbohydrate source becomes increasingly important. The administration of an exogenous carbohydrate source allows for the oxidation of carbohydrate from sources other than muscle glycogen during the later stages of prolonged strenuous exercise (6).

While most of the available evidence indicates exogenous carbohydrate ingestion to be beneficial during moderate intensity aerobic exercise, recent evidence has suggested the use of an exogenous carbohydrate source to also be of benefit during high intensity exercise performance (7-10). By mediating favorable alterations in blood glucose concentration, muscle glycogen depletion during exercise of shorter (i.e.,  $\leq 60$  min) duration and higher (i.e.,  $\geq 80\%$   $\text{VO}_2\text{max}$ ) intensity is reduced. As a result of this glycogen sparing, sprint performance at the end of an exercise activity is enhanced (10).

Hargreaves et al. (10) exercised 10 male subjects (mean  $\text{VO}_2\text{max}$ ,  $4.43 \pm 0.13$  L/min) for a total of 4 hr on a cycle ergometer with intermittent stages of moderate and high intensities. Sprint performance at the end of each trial was 45% longer when the subjects were supplemented with carbohydrate.

Below et al. (8) studied 8 endurance-trained (mean  $\text{VO}_2\text{max}$ ,  $4.44 \pm 0.08$  L/min) males. These subjects cycled for 50 min at  $80\%$   $\text{VO}_2\text{max}$ . During the trials in which they received a carbohydrate supplement, they received  $79 \pm 4$  g of a carbohydrate-electrolyte beverage. A cycling performance test followed in which the subjects were required to complete predetermined amounts of work in the shortest amount of time possible. Subjects were asked to perform a cycling task for 10 minutes at a work rate 10% above their individual lactate threshold. Fluid and carbohydrate ingestion were both found to improve cycling performance, with the effects being additive. These researchers found carbohydrate ingestion to improve sprint performance following

high intensity exercise.

Ball et al.(7) also examined the effects of carbohydrate feeding on the cycle ergometer sprint performance of 8 trained male cyclists. Intensity of exercise prior to measured sprint performance was also set at  $80\%$   $\text{VO}_2\text{max}$  for 50 min of cycle ergometry. Sprint performance was improved with the intermittent ingestion of a carbohydrate supplement providing approximately 53 g CHO/hr.

Most of the previous carbohydrate research has been focused on male athletes. Since there is little research investigating the impact of carbohydrate supplementation upon high intensity exercise performance in females and since our laboratory previously demonstrated that male cyclists enhance their sprint performance with CHO supplementation (7), the current study was proposed. It was hypothesized that the sprint capacity of female cyclists would be enhanced following exogenous carbohydrate consumption during 50 min of high intensity cycling.

## **METHODS**

### **Subjects**

Ten trained eumenorrheic female cyclists with a  $\text{VO}_2\text{max}$  of at least 40 ml/kg/min gave their informed consent to participate in this study. All female cyclists were recruited from the New England and New York areas.

### **Testing Apparatus**

Subject body height (cm) and weight (kg) were determined using a Detecto scale. Subject body composition was determined using Lange skinfold calipers. Subject heart rate was measured with a Polar Vantage XL Heart Rate Monitor (Stamford, CT Model #45900).

A mechanically braked Monark cycle ergometer (Model #864) was used to perform both the  $\text{VO}_2\text{max}$  test and the cycling protocols. The Monark cycle ergometer was retrofitted with a Turbo Saddle

by Vetta (Vicenza, Italy). Platform pedals were replaced with strapped toe clips and cycle ergometer handle bars were replaced with Extreme Handlebars by Scott (Sun Valley, ID). To measure pedal revolutions an optical sensor was interfaced with an IBM compatible computer using SportsMedicine Industries™ (SMI, St. Cloud, MN) software.

A SensorMedics Energy Expenditure Unit (2900 System, Yorba Linda, CA) was used to measure expired volumes of oxygen and carbon dioxide. The plasma concentrations of blood glucose and blood lactate were measured using a Reflotron (Boehringer Mannheim Corp., Indianapolis, IN) and YSI Lactate Analyzer (Model 1500-L, Yellow Springs, OH), respectively.

#### **VO<sub>2</sub>max Test**

The cycling VO<sub>2</sub>max test was a continuous protocol which consisted of 3-min stages beginning with a resistance of 1 kilopond (Kp), and increasing by .5 Kp with every subsequent 3-min stage. Throughout the test subjects pedaled at a cadence of 90 rev/min. The VO<sub>2</sub>max was established when at least two of the following conditions were met: (a) a plateau or a decrease in oxygen uptake associated with an increase in workload; (b) an R value greater than 1.15; (c) a heart rate within 10 beats of the age predicted maximum (11); or (d) a blood lactate concentration of at least 8 mmol/L.

#### **Procedures**

Prior to testing, all subjects completed and signed consent and medical history questionnaire forms. Diet (three day) and training logs were requested from each subject prior to each experimental trial. The diet logs were analyzed using the Nutritionist III Version 7.0 (N-squared computing, Salem, OR). This was done in order to determine the calorie intake and the percentages of carbohydrate, fat, and protein which were ingested prior to the treatment trials. To ensure that testing was conducted during the follicular phase of the menstrual cycle, subjects completed a menstrual history form. Subjects came to the laboratory to complete their first experimental

session during the first 2 days of their menses. Subsequently, the second session was completed 7 days later.

The subjects performed a total of three tests on a mechanically braked Monark cycle ergometer. The first test was performed to measure the VO<sub>2</sub>max of the subjects. Subjects fasted for a minimum of 12 hours prior to performing two separate treatment trials one week apart but administered at the same time of day. During the treatment trials the subjects were given, in a counterbalanced and double blind fashion, either a 7% solution of glucose polymer solution containing maltodextrin (Exceed) or a placebo solution (PL) containing artificial sweetener and flavoring (Crystal Light). All subjects consumed the given treatment in a volume that was set at 2 mL/kg body weight. This equated to the consumption of 440 to 604 mL during exercise. The CE or PL solutions were given at 10, 20, 30, and 40 min intervals throughout the 50 min of exercise at 80% VO<sub>2</sub>max (based on workload). All fluids were kept refrigerated until the time of consumption.

Blood glucose and lactate were collected at baseline, 23 min, and 46 min during exercise via capillary puncture (12). Both respiratory exchange ratio (RER) (13) and RPE (14) values were obtained at 2-min intervals throughout exercise, averaged into 15-min intervals, and subsequently analyzed at min 15, 30, and 45 of exercise.

Immediately following both 50-min cycle ergometer sessions at 80% VO<sub>2</sub>max, a Wingate Anaerobic Power Test (WAT) (15) was administered. With the use of an optical sensor, interfaced with an IBM compatible computer and software by SportsMedicine Industries™ (SMI, St. Cloud, MN), flywheel revolutions were counted and recorded by reading 16 evenly spaced reflectors on the flywheel of the Monark cycle ergometer. As a result, four indices of the WAT were obtained and recorded for analysis: (a) peak power, highest mechanical power

elicited during the test; (b) mean power, the average power which was sustained throughout the 30-s test; (c) minimum power, the lowest mechanical power elicited during the test; and (d) rate of fatigue, the percent difference between the peak power and minimum power.

**Table 1: Descriptive statistics of female cyclists (N = 10)**

Variable	Mean $\pm$ SD	Min.	Max.
Age (yr)	30.40 $\pm$ 7.90	20.00	42.00
Height (cm)	168.15 $\pm$ 4.29	160.02	175.26
Weight (kg)	63.38 $\pm$ 7.28	55.00	75.50
Body Fat (%)	17.42 $\pm$ 2.69	14.00	22.90
VO <sub>2</sub> max (ml/kg/min)	47.13 $\pm$ 3.75	40.34	52.89

**Table 2. RER collapsed across treatments and RPE data during CE and PL trials.**

Variable	15 Min	30 Min	45 Min
RER	.95 $\pm$ .06*	.96 $\pm$ .07	.99 $\pm$ .07**
RPE (PL)	3.9 $\pm$ 1.1§	5.1 $\pm$ 1.5	5.5 $\pm$ 1.9
(CE)	4.2 $\pm$ 1.4	4.7 $\pm$ 1.6	5.1 $\pm$ 2.1

\* Min 15 less than minutes 30 or 45 ( $p < .05$ )

\*\* Min 45 higher than min 30 ( $p < .05$ )

§ Min 15 less than minutes 30 or 45 ( $p < 0.05$ )

**Table 3. Data from the Wingate test.**

Variable	PL	CE
Peak power (watts)	491.5 $\pm$ 101.9	508.2 $\pm$ 99.4
Mean power (watts)	425.7 $\pm$ 72.7	431.7 $\pm$ 63.3
Minimum power (watts)	356.6 $\pm$ 47.5	361.9 $\pm$ 36.0
Rate of fatigue (%)	26.0 $\pm$ 9.2	27.2 $\pm$ 10.7

### Statistical Analysis

A series of dependent samples t-tests were used to analyze the dietary intakes 3 days prior to each of the two experimental testing sessions involving either the CE or an aspartame flavored water placebo. A series of 2 X 3 (treatment X time) repeated measures ANOVAs were used to analyze blood glucose, blood lactate, RER, and RPE obtained for the CE and PL treatment conditions. A dependent groups t-test was performed to analyze

the Wingate Anaerobic Power Test indices of peak power, mean power, minimum power, and the rate of fatigue for the CE and PL treatment conditions. A Fisher's LSD was run as a post hoc multiple comparison method to determine which mean values differed for variables that had a significant treatment x time interaction. The 0.05 alpha level was used for all statistical comparisons.

## RESULTS

All data are presented as means  $\pm$  SD. Descriptive data for subjects are presented in Table 1. The subjects of the study were moderately endurance trained with above average VO<sub>2</sub>max and below average body fat values. The results of the paired samples t-tests yielded no significant ( $p > .05$ ) differences between the two treatment conditions for total calories; grams of carbohydrate, fats, and proteins; and percentage of calories from carbohydrates, fats, and proteins.

### Blood Glucose

A significant interaction for treatment condition by time was found for blood glucose levels [ $F = 5.93$ , Table F (2, 16) = 3.63,  $p = .012$ ]. No significant ( $p >$

.05) difference was found between the carbohydrate-electrolyte beverage (CE) and the placebo (PL) at baseline and min 23. However, mean blood glucose was found to be significantly ( $p < .05$ ) higher for CE than PL at min 46 of the time trial (see Figure 1).

### Blood Lactate

There was neither a significant treatment by time interaction nor a treatment effect (CE vs PL) for blood lactate; therefore, data were collapsed across groups and are presented in Figure 2. There was a significant time effect. Lactate levels were not different between min 23 and min 46, but levels were elevated above baseline at minutes 23 and 46.

### RER

There was neither a treatment by time interaction nor a treatment effect on RER. A significant ( $p < .05$ ) time effect was found in mean RER across the

three averaged 15 min intervals. Significant ( $p < .05$ ) differences were found between all comparisons. Minutes 30 and 45 were both found to be significantly ( $p < .05$ ) higher than min 15. Min 45 was also found to be significantly ( $p < .05$ ) higher than min 30 (see Table 2).

**RPE**

A significant treatment by time interaction was found for RPE [ $F = 6.07$ , Table F (2, 18) = 3.55,  $p = .010$ ]. Post hoc analyses indicated that there was no significant difference in RPE values across time for the CE treatment condition [ $F = 2.62$ , Table F (2, 18) = 3.55,  $p = .10$ ]. However, for the PL treatment condition, significant ( $p < .05$ ) differences were found for RPE scores across the time intervals [ $F = 8.73$ , Table F (2, 18) = 3.55,  $p = .00$ ]. No significant ( $p > .05$ ) difference was found in mean RPE between min 30 and min 45. However, both minutes 30 and 45 were found to be significantly ( $p < .05$ ) higher than min 15 for the PL group (see Table 2).

**Sprint Performance**

Four indices of performance were obtained from the WAT and evaluated. No significant difference was found between the CE and PL treatment conditions. Data are presented in Table 3.

**DISCUSSION**

Following a 12 hour fast, liver glycogen is dramatically reduced (4). Therefore, there would be a tendency for plasma glucose levels to be reduced if an exogenous source of glucose is not ingested during prolonged exercise. In this study, as

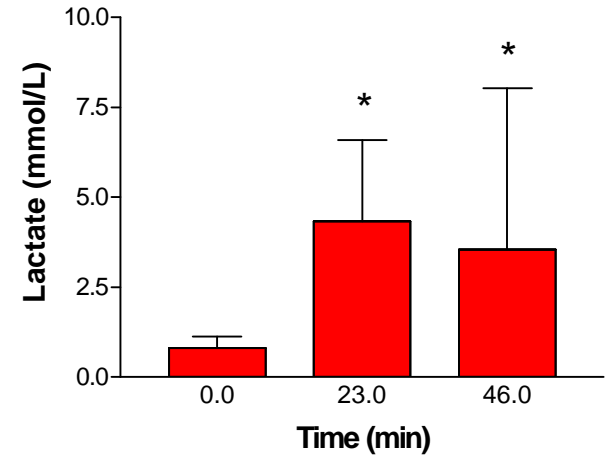
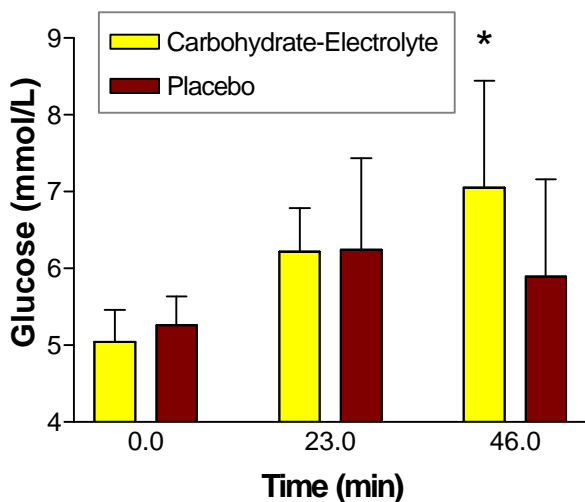


Figure 2: Plasma lactate mean data collapsed across both trials. \* =  $p < 0.05$  from baseline (time = 0).

expected, blood glucose levels were higher in the CE trial than in the PL trial. This did not result in higher WAT scores, although it might have affected the perceived effort (i.e., RPE) of the subjects. In addition, fatigue rate was not significantly different between the two trials.

RPE is a variable that gives an indication of the perceived difficulty of the work performed by the subjects (14). The significant treatment by time interaction indicated that RPE increased more during the PL trial than the CE trial. Therefore, the subjects did not feel as if they were working as hard during the later stages of the 50 min ride as a result of the periodic consumption of the CE drink during exercise. Consumption of a carbohydrate beverage appears to decrease the perception of fatigue.

Figure 1: Blood glucose concentrations for the two drink solution trials. \* =  $p < 0.05$  between CE vs PL

During the 50 min ride, there was an increase in RER. This would suggest that over time, there was a relative increase in the rate of carbon dioxide production compared to oxygen consumed. Carbon dioxide is produced as a byproduct of respiration,

with more resulting from carbohydrate than fat catabolism, or as a result of the buffering of free protons by bicarbonate. From the results of this study, it is very difficult to determine which of these is responsible for the observed rise in RER.

Gender differences may account for the discrepancy between the results of the current investigation, which used female cyclists, and previous studies of a similar nature, which used male cyclists (7,8). In the current study as well as those of Ball et al.(7) and Below et al.(8), subjects intermittently ingested a carbohydrate electrolyte beverage and performed 50 min of cycle ergometry at 80%  $\dot{V}O_2$ max followed by a high intensity “sprinting” test. Unlike the current study, carbohydrate ingestion enhanced sprint performance in the aforementioned cyclists (7,8).

It is also important to note that in this study, as was the case in the Ball et al.(7) study, subjects were given the same relative dose (i.e., 2 ml/kg) of the identical carbohydrate electrolyte beverage. For the males, this was equivalent to the consumption of carbohydrate at the rate of approximately 53 g/hr compared to 36 g/hr in the females. Therefore it is possible that the female subjects may have received the carbohydrate supplement at a rate that was below the minimum threshold needed to have an ergogenic effect (16).

Tarnopolsky et al. (17,18) have shown that trained females oxidize lipids at a greater rate during submaximal exercise than equally trained males. This same group of researchers have also shown that trained female endurance athletes show a blunted increase in intramuscular glycogen and virtually no increase in performance following a period of carbohydrate loading when compared to males (17). These findings are consistent with the observations of the current study.

The ovarian hormones (estrogen and progesterone) are thought to have significant effects upon substrate

utilization during exercise (19). Estrogen has been shown to enhance lipid oxidation which has a carbohydrate sparing effect (20). The levels of these steroid hormones vary in a relatively predictable manner during a 28-34 day cycle. Therefore, substrate use is influenced by the phase of the menstrual cycle in which exercise is performed (21). In the present study, all subjects were tested during the follicular phase of their menstrual cycles at a time when estrogen levels are thought to be low and the confounding effects of progesterone are minimal (21,22). During the luteal phase of the menstrual cycle, both estrogen and progesterone levels are high, and glycogen sparing is enhanced (23). However, even during the follicular phase (when estrogen is generally lower), females still derive a greater proportion of energy from fat and utilize less carbohydrate than males (18). This greater reliance upon fat may be directly related to estrogen's effect upon fat metabolism or indirectly via its action upon human growth hormone (22).

The use of an oral contraceptive (OC) by a female athlete can have an effect on energy substrate usage during exercise. OCs have been shown to influence growth hormone, and plasma glucose levels (24). These observed responses suggest that OCs have a carbohydrate sparing effect (24). Since five of the ten subjects in the present study were using some form of an OC this may have had an effect on substrate metabolism and the WAT scores.

It is also possible that the inclusion of more subjects would result in a different outcome. A power analysis indicated that it would have taken approximately 15 (power=70%) to 23(power=90%) female subjects to detect a treatment difference in this study. In contrast, in males, treatment effects have been detected with the use of as few as 8 subjects (7).

In conclusion, the feeding of a 7% CE solution (in the same relative dosage as in males) does not

significantly improve short term (i.e., < 60 min) high intensity (i.e., > 80% VO<sub>2</sub>max) exercise performance of trained female subjects. This may be caused by gender differences in substrate utilization during exercise. A higher relative dose of carbohydrate may be required to produce an ergogenic effect during high intensity exercise in females.

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