

INFLUENCE OF MENSTRUAL CYCLE PHASE ON CARBOHYDRATE SUPPLEMENTATION DURING EXERCISE TO FATIGUE

K. Mittleman, I. Rangwalla, C. Zacher, J. Polizzi, M. Cohen, J. Burgin, and S.P. Bailey

Rutgers University, New Brunswick, NJ; Medical University of South Carolina, Charleston, SC, USA

INTRODUCTION

Elevated levels of estrogen and progesterone which characterize the luteal phase of the menstrual cycle are associated with decreased muscle glycogen and enhanced free fatty acid utilization during exercise (1,2). Although this shift in substrate is beneficial during moderate intensity exercise, performance at higher intensities may be adversely affected. Also, increased plasma free fatty acids (FFA) may enhance the availability of tryptophan (plasma free-tryptophan; F-TRP) to the brain. F-TRP, precursor of the neurotransmitter serotonin (5-HT), has been hypothesized to mediate central fatigue during prolonged exercise (3).

Studies in men who performed cycle exercise ($70\% \dot{V}O_{2\max}$) to exhaustion have shown that fluid supplementation with carbohydrate (CHO) improved performance times (4,5). Davis *et al.* (5) reported a reduced ratio of F-TRP to branched-chain amino acids (BCAA; leucine, isoleucine, valine) with CHO, potentially delaying central fatigue.

Since behavioral susceptibility to changes in brain 5-HT activity may be influenced by sex (5), the purpose of this study was to evaluate the effect of carbohydrate supplementation on fatigue during prolonged endurance exercise in follicular and luteal phases of the menstrual cycle.

METHODS

Nine active, eumenorrheic females (26 ± 7 yr; 60 ± 8 kg; 20 ± 3 % fat; 50 ± 4 ml·kg⁻¹·min⁻¹ ($\dot{V}O_{2\max}$) participated in the study. A graded exercise test on a cycle ergometer (Schwinn Velodyne) was used to determine maximal oxygen consumption ($\dot{V}O_{2\max}$) and to quantify the relative workrate ($70\% \dot{V}O_{2\max}$) for subsequent endurance trials.

Subjects underwent 4 trials, 2 during the follicular phase (FOL, days 1-8) and 2 during the luteal phase (LUT, days 19-26) of their menstrual cycle. During each trial subjects received 5 ml·kg⁻¹ of a beverage containing a 6% carbohydrate solution (CHO) or a flavored placebo (PLAC). Drinks were administered in a double-blind fashion using a Latin-square design.

Subjects ingested a standardized breakfast and reported to the laboratory 4 h postprandial. Core temperature (T_{es}), mean skin temperature (\bar{T}_{sk}), heart rates (HR) and mean arterial pressure (MAP) were measured at regular intervals. Ratings of perceived exertion (RPE) and blood samples were taken every 30 min. After 30 min of baseline, blood was drawn then subjects cycled until fatigue. Data were compared between fluid treatments, menstrual cycle phases and over time using a repeated measures ANOVA. Significant interactions ($p \leq 0.05$) were evaluated by least square means.

RESULTS

Exercise time to fatigue during CHO was longer than PLAC for both FOL (199.7 ± 10.6 vs. 160.5 ± 10.5 min) and LUT (181.1 ± 13.8 vs. 161.2 ± 13.7 min) phases. Fatigue was not influenced by menstrual cycle phase.

Plasma glucose and FFA responses are shown in Figure 1. Since these data were not affected by menstrual cycle phase, both PLAC and CHO trials were combined. After the initial drink at min 30, glucose was maintained at a higher level throughout the CHO trial when compared to PLAC. During PLAC, glucose was reduced from baseline at 90 min of exercise and remained at that value until fatigue. A linear increase in FFA from 60 min of exercise was observed during PLAC. This increase was blunted during CHO.

Figure 2 displays RER and RPE data. CHO resulted in a greater RER when compared to PLAC from 90 min of exercise. RPE increased linearly for both drink treatments over time until 2 h of exercise, however, CHO resulted in a reduced response at each time point. At fatigue, RPE was similar between drink treatments.

Although T_{es} was higher during baseline for LUT when compared to FOL for both drink treatments (36.8 ± 0.1 vs. $36.6 \pm 0.1^\circ\text{C}$), T_{es} at fatigue was similar for all trials ($37.8 \pm 0.3^\circ\text{C}$). MAP (92.8 ± 1.3 mmHg), HR (157 ± 3 bpm) and \bar{T}_{sk} ($32.9 \pm 0.3^\circ\text{C}$) responses at fatigue were not different between drinks or menstrual phases.

CONCLUSIONS

These results indicate the beneficial effect of carbohydrate supplementation during prolonged cycle exercise to fatigue in women is not influenced by menstrual cycle phase. Women in this study responded similarly to men (5) in both prolonged time to fatigue as well as the blunted FFA response during carbohydrate supplementation. The reduced RPE we observed with glucose ingestion agrees with previous studies during submaximal exercise in males (7).

We did not observe menstrual phase differences in cardiorespiratory or psychological responses throughout prolonged exercise or at fatigue. These results are in contrast to Hackney *et al.* (2) who observed a greater respiratory exchange ratio for the follicular when compared to luteal phases during 1 h of submaximal

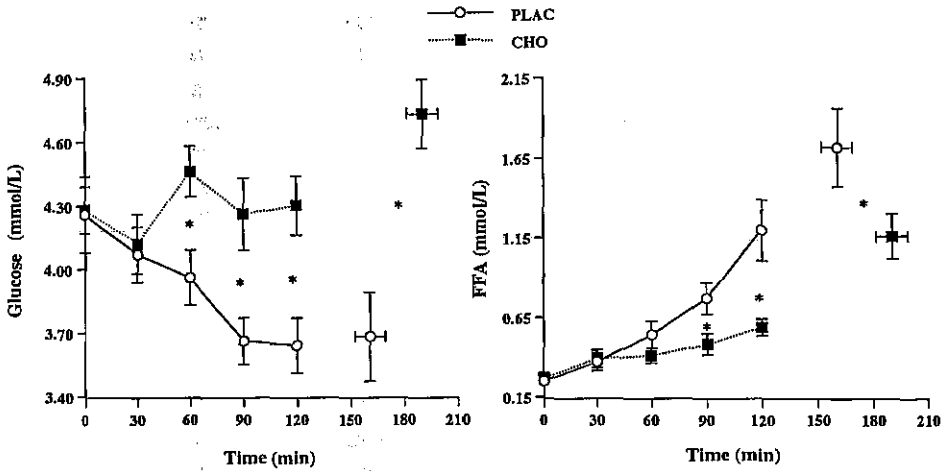


Figure 1: Plasma glucose (left) and FFA (right) responses (mean \pm SEM) are shown over the first 2 h of exercise and at fatigue. No differences were observed for menstrual phase thus PLAC (open circles) and CHO (closed squares) trials were combined for LUT and FOL phases. * $p < 0.05$, PLAC vs. CHO.

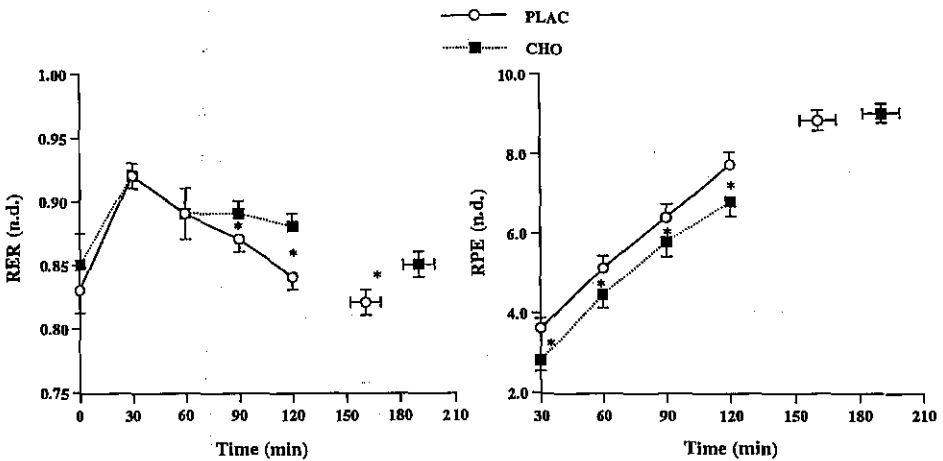


Figure 2: Mean \pm SEM responses for RER (left) and RPE (right) over the first 2 h of exercise and at fatigue. No differences were observed for menstrual phase thus PLAC (open circles) and CHO (closed squares) trials were combined for LUT and FOL phases. * $p < 0.05$, PLAC vs. CHO.

exercise. However, others have also reported no effect of menstrual phase on submaximal exercise responses (8).

The potential beneficial effect of CHO supplementation in reducing FFA and thus F-TRP and its contribution to "central fatigue," cannot be confirmed until analyses of plasma amino acids are completed.

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