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Comparisons of Post-Exercise Chocolate Milk and a Commercial Recovery Beverage following Cycling Training on Recovery and Performance

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ABSTRACT

Pritchett KL, Pritchett RC, Green JM, Katica C, Combs B, Eldridge M, Bishop P. Comparisons of Post-Exercise Chocolate Milk and a Commercial Recovery Beverage following Cycling Training on Recovery and Performance. **JEPonline** 2011;14(6):29-39. A recovery beverage that enhances recovery and either maintains or improves the athlete's workout is highly desired. This study compared low-fat chocolate milk (CHOC) to a commercial recovery beverage (Endurox, CRB) ingested daily over a one-week period in 10 trained cyclists. Cyclists twice maintained their training regimen over a three-week period in which they received either the CHOC or the CRB treatment post workout in a counterbalanced design. Cycling performance at 85% of VO_2 max was compared between the two beverages. CK (creatine kinase) levels were assessed at baseline and before the performance trial. A repeated measures ANOVA indicated that CKpre significantly increased ($P<0.05$) by 64% (+220 UL^{-1}) to CKpost for both trials. However, there was no significant difference ($P = .95$) for CKpost between the two trials (CHOC 570 ± 336 UL^{-1}, CRB 579 ± 383 UL^{-1}). There was no significant difference ($P = .73$) between trials for cycling time to exhaustion at 85% of VO_2 max (CHOC 17.4 ± 13.1 min, CRB 15.5 ± 9.9 min). As a recovery beverage, this study suggests that chocolate milk is just as effective as CRB.

Key Words*:* Sports nutrition, Creatine kinase, Carbohydrate

INTRODUCTION

Post-exercise nutritional strategies have focused on timing, type of beverage, amount, and frequency to determine the most effective way to speed glycogen recovery (14). A recovery beverage is highly desirable, especially one that will maximize muscle glycogen storage both before and after exercise, enhance recovery and either maintain or improve the athlete's workout. According to the American College of Sports Medicine and the American Dietetic Association, consuming 1.0 to 1.5 g of carbohydrate (CHO)/kg of body weight/hour immediately after exercise, and for up to 5 hr post exercise at 15 to 60 min intervals may be crucial for optimizing glycogen resynthesis and recovery (1,13,14,16). The addition of protein (PRO) (~20% of total calories) to a carbohydrate beverage after intense exercise has also been researched to determine if it enhances muscle-glycogen stores and decreases recovery indices (17,22). While some studies have reported improved glycogen repletion following post-exercise CHO-PRO supplementation (3,4,13,28,29), others have observed no effect (15,25). Improved athletic performance and improvements in recovery indices have also been reported, as indicated by elevated creatine kinase (CK) with a CHO:PRO beverage compared to a CHO only beverage given during and after the exercise session (20-24). In contrast, the majority of the studies have examined the effects of a single dose, post-exercise beverage on muscle damage and recovery indices. Very few studies (17,23) have examined the effects of a post-exercise nutritional beverage taken over time (6 d) on muscle damage.

According to Karp et al. (16), chocolate milk (CHOC) was significantly more effective in enhancing recovery, and improving performance compared to an over-the-counter recovery aid (Endurox) when recovery time was short (~4 hours). The authors concluded that the performance difference noted in the study may have been due to the differences in type of carbohydrate composition between the beverages. Chocolate milk contains the monosaccharides glucose and fructose and disaccharides (lactose in particular; it is formed by one molecule of galactose and one molecule of glucose coupled by a Beta linkage), while the commercially-available recovery beverage consists of monosaccharides (glucose and fructose) and complex carbohydrates (maltodextrin). Chocolate milk (CHOC) has a calorie content and a CHO:PRO ratio (4:1) similar to many commercial recovery and carbohydrate replacement beverages (CRB) (e.g., Endurox). Depending on the brand, a 70 kg athlete would need to consume 510 to 810 ml of low-fat chocolate milk (providing 70 to 84 g of carbohydrate, and 19 to 30 g of protein) to meet post-exercise recommendations (14,16). Also, consuming chocolate milk is advantageous to athletes with limited time between workouts or competition because it is pre-mixed, readily available, and relatively inexpensive (16,24). It is possible that regular use of chocolate milk post workout could easily be employed in a training regimen. Hence, the single use of a recovery beverage, used in the study by Karp et al. (16) study may have resulted in the under-estimation of the true potential on recovery.

The purpose of the present study was to compare the effects of chocolate milk to a commercial CHO:PRO beverage post workout over a longer period of time to simulate a normal training regimen as compared to a single dose. This thinking is particularly important since prolonged endurance exercise can damage skeletal muscle, thus resulting in a delayed onset muscle soreness with concurrent increases in markers of muscle damage such as creatine kinase (CK) (6,27). Elevated levels of these markers are associated with decreased performance (27). Due to the applied nature of the recovery studies, the majority of the literature regarding muscle damage CK and subjective measures of muscle soreness using a numerical pain scale (17). The current study was therefore designed to address the following hypotheses: Due to the similar CHO:PRO ratio of chocolate milk and the CRB, post-exercise consumption of chocolate milk for 1 wk will be as effective in attenuating markers of muscle damage (CK) and muscle soreness when compared to the CRB beverage, and chocolate milk will be as effective as the CRB in enhancing time to exhaustion at 85% of VO_2 max when consumed for 1 wk post workouts.

METHODS

Experimental Approach to the Problem

The effects of two post-exercise recovery beverages (CHOC and CRB) taken for 1 wk post workout were compared in a counterbalanced repeated-measures crossover design. Recovery measures after a weeklong workout were: (a) cycling performance at 85% of VO_2 max until exhaustion; (b) muscle soreness; and (c) reduction of muscle damage markers (CK). Because the mood changes and performance of competitive athletes are less likely to vary, they were used to improve sensitivity and the external validity of the study. All subjects reported to the Human Performance Laboratory for familiarization and measurements of skinfold, VO_2 max, height, and body weight. The subjects performed the protocol on two occasions, each lasting 1 wk with at least a 1 wk wash-out in between.

Subjects

Ten recreationally trained cyclists between ages of 19 to 40 who trained at least 6 hr/wk with at least 2 yr experience in endurance sports were recruited to participate in this counterbalanced, cross-over repeated-measures study. All subjects were trained club cyclists (n = 9) or trained tri-athlete (n = 1). Any subjects who were using supplements were excluded from the study. Their descriptive characteristics are presented in Table 1. Upon arrival to the lab, subjects were fully informed of the procedures and risks associated with the research procedures. A written informed consent was obtained from each subject before participation. None of the subjects was advised as to the direction of the researchers' hypotheses.

Ten endurance trained male cyclists and triathletes completed the study. Based on data from previous studies (17,21,22), an alpha level of 0.05, a statistical power of .80, and an estimated effect size of 10% (a standard deviation of 200 for CK, and 2 for muscle soreness) an a priori power analysis indicated a need for 6 subjects. Ten subjects were used to ensure sufficient statistical power. All procedures were approved by The University of Alabama IRB, and The University of Central Washington IRB. Participants were also instructed to refrain from intense exercise for 24 hr prior to the first testing session.

Procedures

Each subject completed two counterbalanced, 1 wk long intervention periods with a 1 wk wash-out between each treatment. The treatments were counterbalanced so that half of the participants received the CRB during the first intervention and, then, received the chocolate milk for the second, and vice versa. During the first treatment period, the subjects followed a similar training plan. Throughout the week-long training period, subjects received either CRB (Endurox R4, PacificHealth Labratories, Woodbridge, NJ) or low-fat chocolate milk (CHOC) (Mayfeild, Athens, TN) (Table 2) based on the post-exercise recommendations for 1 g CHO/kg of body weight (13,14,16) immediately after their workout and again at 2 hr into the recovery period. Subjects were instructed to record training information (i.e., distance, time, pain using a 1-10 visual analog scale), and rating of perceived exertion (RPE)) during the week. At the end of 1 wk, the subjects completed a trial on the cycle ergometer at 85% of VO_2 max until exhaustion (22). Subjects completed a 5-min warm-up prior to the time trials. For both trials, CK was measured at baseline and again before the performance test. Heart rate (Polar, Electro Inc Finland) was assessed at each minute during the time trial to exhaustion for both treatments. After a 1-wk washout period between the two interventions, participants completed the second training period with a different post-exercise beverage. The same measurements (listed below) were taken for each treatment.

Training periods

To maintain uniformity, the subjects completed identical 7-day (Monday to Monday) training programs during the 3 wk of the investigation period. They were instructed to maintain an average of 32 kilometers of cycling per day. Training was prescribed based on experience and ability of each subject. However, consistent training levels were maintained within subjects during the two treatment and washout periods. Training intensity was compared during the two interventions using RPE, and a pain scale (1-10 visual analog scale) on day two and four during workouts. Subjects also kept a 3-day food record during each intervention period to confirm that diet was similar between the two treatment periods. Sleep patterns were also assessed upon waking on day two and four during the training period using the Stanford Sleepiness Questionnaire (1 = awake, 7 = extremely sleepy) (12).

Recovery Beverages and Dietary Controls

Subjects consumed the recovery drinks (chocolate milk or CRB) immediately following the first exercise session, and again 2 hr into the recovery period, daily. The same amount of CHO was given at each period (1.0 g CHO/kg of body weight/h) after exercise and again at 2 hr during recovery for the CRB and CHOC treatments (Table 2). Table 4 presents the mean amount of kcals, CHO (gm), protein (gm), and fat (gm) between the two trials. The beverages were isocaloric for grams of CHO and protein between the two treatments (CRB, and CHOC). The low-fat chocolate milk used in this study consisted of sucrose (glucose plus fructose), lactose (glucose plus galactose), high fructose corn syrup, and cocoa (Fred Meyer). CRB used in this study (Endurox R4, PacificHealth Labratories, Woodbridge, NJ) consisted of complex carbohydrates (maltodextrin), glucose, whey protein, crystalline fructose, L-Arginine, dl-Alpha tocopherol acetate, ciwujia, ascorbic acid, sodium chloride, citric acid, L-Glutamine. Subjects were given an unmarked bottle which contained the recovery beverage (CHOC, CRB) to carry throughout the intervention. Subjects were allowed to drink water ad lib during the 2 hr recovery period, but no other food or drink was allowed during the recovery period. Treatment beverages were repeated using the same procedures every day for 6 days of each treatment week. Beverage preference was assessed at the end of the study to determine which beverage the subjects preferred. The subjects were asked to replicate the same dietary habits during each treatment period. Each subject completed a three-day food record during each trial, which was analyzed using Diet Analysis Plus 8.0 (Thomson) software for total kilocalories, carbohydrate (gm), protein (gm), and fat (gm) intake.

Measurements

Age (yr), height (cm), and mass (kg) were recorded with body fat percentage estimated using Lange skinfold calipers (Cambridge, Md, USA) and a 3-site method (chest, abdomen, and thigh) (18). Rating of perceived exertion was determined using a 6 to 20 point scale (5). The RPE was taken during the 2nd and 4th workouts for each treatment. Muscle soreness was assessed using a 10-cm visual analog scale (7) with anchor points “no pain at all” at the left end and “unbearable pain” at the right end, and was taken on the same two days of each treatment. The Stanford Sleepiness Scale (SSS) (12) was used to determine degree of sleepiness using a 1 to 7 scale (with 7 being very sleepy). The subjects’ dietary records were analyzed for carbohydrate, protein, and fat composition using a computer software program (Diet Analysis Plus 8.0, Thomson) to confirm that the subjects’ diets were similar within subjects during the two treatments. Baseline blood samples for CK were obtained before the first cycling session (PRE) on Monday and before the time trial (POST) for both interventions (CRB and CHOC). The POST blood draw was timed to be collected ~24 hr after Sunday’s workout to capture elevated post workout CK levels for comparison between the two interventions (22). Peak accumulation for CK levels has been indicated to occur anywhere from 6 to 24 hr after exercise (8,11,22). For the purpose of this study, CK levels were examined ~24 hr after the final workout session and before the time trial based on a study by Luden et al. (17). The samples consisted of 0.025 ml of blood obtained from the fingertips using a lancet (Becton Dickinson, Franklin

Lakes, NJ). A blood sample was collected at the fingertip using a plasma separator tube (Becton Dickinson, Franklin Lakes, NJ) before the beginning of the first exercise session (PRE) to determine baseline CK levels. The blood samples were spun in a Precision Durafuge 200R centrifuge (Thermo Scientific) to separate the plasma. Blood samples were analyzed for CK absorbance difference per minute using a Genesys 10 Series analyzer (Thermo Spectronic, Rochester, NY). To ensure reliability, each sample was analyzed in duplicate with serial samples no greater than 0.2 mmol·L^{-1} apart. The average of the two samples was used for analysis. Before CK analysis, the Gensys 10 Series was calibrated prior to each trial by the means of the millimolar absorptivity of NADH taken as 6.22 at 340 nm.

Statistical Analyses

Descriptive characteristics were computed for the subjects. Mean values for RPE, pain, and HR were computed for the two interventions. A within-subject's repeated measures design was employed to contrast the impact of two nutritional interventions on muscle damage (CPK) and performance. Data from the two treatment periods were compared using a two-factor (treatment x time) repeated-measures ANOVA. A Tukey post-hoc test was applied in the case of a significant ($P < 0.05$) *F* ratio to locate the differences with the ANOVA. All statistical analyses were performed using SPSS for Windows version 15.0 software (SPSS, Chicago, USA). All data are reported as means ± SD. Statistical significance was set at alpha <0.05.

RESULTS

Ten endurance trained cyclists completed this study. The descriptive characteristics for the subjects are displayed in Table 1. All subjects confirmed that they were not taking any nutritional supplements prior to beginning the study.

Table 1. Descriptive Statistics for Participants (n = 10)

Variables	Means ± SD
Age (yrs)	26.9 ± 7.9
Height (cm)	177.5 ± 4.8
Weight (kg)	73.5 ± 8.7
Body Fat (%)	10 ± 4.5
VO2max (ml•kg•min^{-1})	55.2 ± 7.8
Watts (85% trial)	331 ± 45.9

Average macronutrient content for the recovery beverages (CHOC and CRB) taken after each trial is displayed in Table 2. There were no significant differences between the two beverages for calorie, carbohydrate and protein content. However, there was a significant difference in fat (gm) content ($P < 0.01$) between the beverages (CHOC 4.6 ± 1.5 gm, CRB 2.7 ± 1.5 gm). After the completion of the study, the subjects were asked to provide subjective feedback about the beverages. Ten out of 10 subjects preferred the taste and consistency of chocolate milk.

The subjects were told to match dietary intake for each trial. There were no significant differences in macronutrient intake (kcals, carbohydrate, protein, and fat) between the two trials (Table 3). There were no significant differences in sleep patterns between the two trials on day 2 (CHOC 3.0 ± 1.1, CRB 2.56 ± 1.1) (P = .9) and day 4 (CHOC 2.9 ± 1.3, CRB 3.0 ± 1.0) (P = .85) using the Stanford Sleepiness Questionnaire. There were no significant differences in muscle soreness on day 2 (CHOC 2.8 ± 1.7, CRB 2.8 ± 1.4) (P = .99) and day 4 (CHOC 4.1 ± 2.1, CRB 3.8 ± 2.0) (P = .74) between the two trials. RPE on day 2 (CHOC 12.6 ± 3.7, CRB 11.0 ± 3.2) and day 4 (CHOC 13.0 ± 3.0, CRB 12.6 ± 3.7) were not significantly different (P = .34, P = .77) between treatments. Training was matched for the two trials; daily average kilometers for CHOC (38.8 ± 6.4), and CRB (36.4 ± 4.5) were not significantly different (P = .53). There was no significant difference (P = .73) between trials for cycling time to exhaustion at 85% of VO_2 max (CHOC 17.4 ± 13.1 min, CRB 15.5 ± 9.9 min).

There was no significant (P = .87) difference for CKpre between the two trials (CHOC 345 ± 244 U/L^{-1}, CRB 363 ± 223 U/L^{-1}). CKpre significantly (P <0.05) increased by 64% (+220 UL^{-1}) to CKpost for both trials. However, there was no significant difference (P = .95) for CKpost between the two trials (CHOC 570 ± 336 U/L^{-1}, CRB 579 ± 383 U/L^{-1}) (Figure 1). Furthermore, there was no main effect or interaction (treatment x time) (P = .87) observed for this study.

Table 2. Nutrient composition of recovery drinks.

	CHOC	CRB
Energy (kcals)	411 ± 49.7	396 ± 49.7
Carbohydrate (g)	73.2 ± 8.7	73.2 ± 8.7
Protein (g)	19.1 ± 2.3	19.4 ± 2.3
Fat (g)	*4.6 ± 1.5	*2.7 ± 1.5
Volume (ml)	531 ± 63	531 ± 63

Values are mean ± SD. Values include macronutrients in the recovery beverages. No significant differences were observed between the trials.

Table 3. Average daily dietary intake (kcal, CHO, protein, and fat) between subjects for each trial (n = 10).

	CHOC	CRB
Energy (kcals)	2770 ± 455.1	2641 ± 2.1
Carbohydrate (g)	387 ± 69.5	370 ± 60.5
Protein (g)	127 ± 19.9	118 ± 28.9
Fat (g)	76 ± 15.9	64 ± 21

Values are mean ± SD. Amount of beverage ingested immediately after exercise and 2 hr into the recovery period. Amount of beverage given based on body mass (1.0 gm CHO/kg).*Significar differences (P<0.05) between fat (gm) for eac beverage.

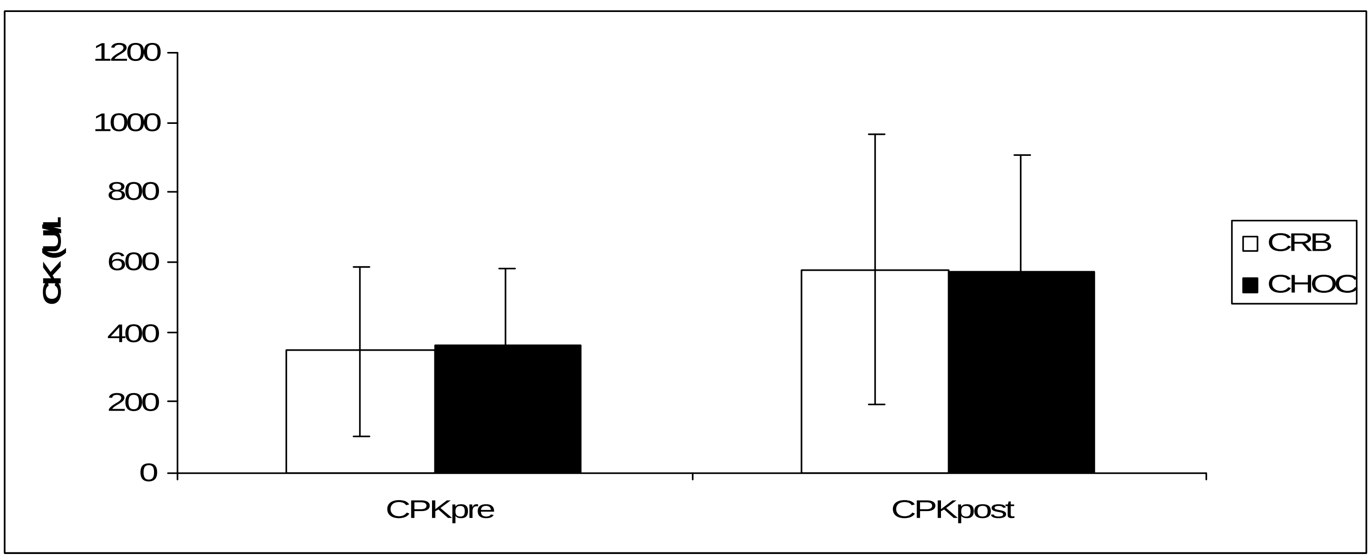

Figure I. Pre and post CK levels for each trial. No significant difference between the trials. A significant (P <0.05) difference was observed between pre and post CK levels for each trial. Values are mean ± SD.

DISCUSSION

Since muscle glycogen is the primary substrate used during intense exercise, replenishing muscle glycogen stores in the post-exercise recovery period is an important factor influencing recovery and performance. The primary aim of many commercially available supplements is to enhance recovery and maximize training during daily workouts. The main finding of this study is that there was no significant difference between beverages for performance or markers of muscle damage after a week of post-exercise supplementation. The current study was designed to compare the effects of two recovery beverages, CHOC and CRB, taken over a 1 wk period on markers of muscle damage, and endurance performance during a time trial to exhaustion at 85% of VO_2 max. Research has examined whether or not the addition or PRO to a CHO beverage reduces muscle damage indices and enhances recovery (11,22,28). The proposed mechanism for which the addition of protein may enhance recovery is two-fold: increases insulin levels (26); and promotes net skeletal-muscle protein synthesis (11,26). However, the literature examining the effects of two recovery beverages matched for CHO and protein content on markers of muscle damage in trained cyclists is sparse. The majority of the studies have only examined the acute effects of a post-exercise recovery beverage. From a practical standpoint, this study was designed to simulate day to day training over time with a recovery beverage incorporated.

The recovery beverages used in our study provided equal amounts of CHO and protein. There was no significant difference in calorie content between CHOC (411 calories) and CRB (395 calories). The differences in calorie content can be attributed to the additional fat in the CHOC. It is questionable the impact this difference in fat content may have had on glycogen repletion and circulating free fatty acids.

Muscle Damage

Few studies have examined the efficacy of a post-exercise nutritional beverage taken over time (~6 days) on muscle damage (10,17,23). Luden et al. (17) examined the effects of CHO:PRO beverage with antioxidants (CHO:PRO:A) compared to a CHO-only beverage over a 6 day period in runners, and found significantly ($P < 0.05$) lower CK levels with a CHO:PRO:A beverage (223 ± 161 U/L^{-1}) versus the CHO only beverage (307 ± 313 U/L^{-1}). However, there was a 19% difference in the amount of calories between the beverages used in this study (CHO:PRO:A 458 kcals, and CHO 370 kcals). The authors speculated that the amount of muscle damage seen in the study was not enough to negatively affect exercise performance (17). The CK levels observed by Luden et al. (17) were similar to the levels seen in the present study. Therefore, the level of muscle damage in this study may not have been enough to denote any performance differences between the trials.

As expected, we found no differences between the CHOC and CRB trials on markers of muscle damage (CKpre and CKpost). As would be expected, there was a significant increase from CKpre to CKpost, but no difference between the two trials. A control trial was not used in the current study because it is well established that a post-exercise meal provides more benefit than consuming nothing at all (14). CKpre significantly increased by 64% at CKpost in the present investigation. It should be noted that the CKpre was obtained after 24 hr of rest. Although, various measures were controlled for during the training session, it is difficult to be definitive about changes in CK values between measures. The differences in our findings from previous studies can be attributed to the fact that the beverages used in the current study had a similar CHO:PRO ratio. In contrast to our findings, Gilson et al. (10) found a significantly lower ($P < 0.05$) CK levels after 4 days of post-exercise supplementation with low fat chocolate milk compared to a high CHO beverage in soccer players. However, measures of muscle soreness and myoglobin were not significantly different between treatments (10).

Decreases in recovery indices have been reported, as indicated by elevated creatine kinase (CK) 12 to 24 hr post-exercise, with a CHO:PRO beverage compared to a CHO only beverage given during and after the exercise session (20-24). These findings suggest that CHO:PRO supplementation may attenuate post exercise muscle damage. However, none of these studies used a muscle biopsy or MRI technique to assess direct measurements of myofibrillar disruption (24). Futhermore, a study by Elliot et al. (9) suggests that ingestion of whole milk after resistance training may have increased utilization of available amino acids for protein synthesis due to an increased uptake of phenylalanine and threonine.

The methods for measuring recovery in this study are similar to the measures used in other studies. Similar to limitations of the aforementioned studies, this study did not address direct measures of muscle damage via muscle biopsy. Furthermore, CK has been criticized as being a good marker of muscle damage because of poor correlations with direct measures of muscle damage. Also, enzyme clearance rates are related to alterations in CK levels (17). CK has been shown to be highly variable among athletes with a coefficient of variation as high as 200% (21). In addition to measuring CK levels, the present study used subjective measures to control for any differences between the two trials. No significant differences in muscle soreness or RPE post workout on days 2 and 4 of training were observed. Future research should incorporate multiple methods of measuring markers of muscle damage, such as measuring lactate dehydrogenase (LDH) and myoglobin levels. Due to the mixed findings, more research is warranted to determine the specific mechanisms for which CHO:PRO supplementation produces practical changes in recovery (24).

Exercise Performance

In addition to examining markers of muscle damage, this study examined endurance performance as a measure of recovery. We hypothesized that there would be no significant difference in time to exhaustion between the two treatments (CHOC and CRB) because of the similar CHO:PRO ratio between the beverages. Similar to other findings (10,17), we observed no differences in performance between the trials.

In contrast to our findings, Karp et al. (16) found that subjects cycled 54% longer with CHOC versus the CRB during a time trial to exhaustion at 70% of VO_2 max. The recovery period in Karp's study was 4 hr compare to the 15 to 18 hr recovery period used in the current study. The authors suggested that because the recovery beverage (Endurox) used in the study consisted of complex carbohydrates, then, perhaps there was not enough time allowed for complete digestion. Then, too, the chocolate milk, a simple carbohydrate, may have delayed glycogen depletion due to a possible increase in circulating free fatty acids from the additional fat in CHOC (16). In contrast, even with longer time for the CRB to be metabolized, the differences in the recovery periods used in Karp et al. (16), which was 4 hr versus the present study (daily) may have contributed to the observed differences in performance between these two studies. Our finding of no differences in performance may be due to the similarity between the beverages used.

Variations in nutritional status prior to participating in the study may have impacted recovery status among individuals. Providing pre-packaged meals in a similar study design to ours would be beneficial for increasing the internal validity of the study, but this may not be practical.

Chocolate milk was just as effective as commercial recovery beverage in attenuating muscle damage during a week-long training session. Also, consumption of chocolate milk as a post-exercise recovery aid resulted in similar performance outcomes to CRB. Chocolate milk may be a useful option for athletes searching for a recovery beverage that is relatively inexpensive and readily available (16). Future research should examine the effects of chocolate milk taken over a longer period of time.

CONCLUSIONS

Based on the results of the present study, chocolate milk seems to be as effective in enhancing recovery as a commercial beverage of lower cost. Because the CHO:PRO ratio of chocolate milk is similar to many commercial recovery beverages, perhaps it could be marketed as an option for athletes searching for a post-exercise recovery beverage.

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