Abstract
Performance improvements have been reported when mouth rinsing with a carbohydrate solution during short duration, high intensity endurance exercise. Limited research has been conducted in this area when endogenous carbohydrate stores are depleted. PURPOSE: The purpose of this study was to assess the effects of a carbohydrate mouth rinse on endurance-trained cyclists in both glycogen depleted and non-depleted states. METHODS: Five endurance-trained men (28±7 years; 179.32±8.15 cm; 68.65±8.16 kg; 54.00±5.95 mL/kg/min VO2 max) participated in a repeated measures crossover study using a CHO mouth rinse (4% maltodextrin) or placebo. RESULTS: Subjects completed the time trial faster (p=0.033) in the non-depleted state, despite reporting lower RPE (p=0.010). There was no significant treatment effect, but subjects completed the time trial 20 seconds faster in the CHO rinse segment interaction (p=0.028). CONCLUSION: CHO mouth rinse may be a valuable tool for performance enhancement in suboptimal nutrition states. 

Innovation
Introduction
Carbohydrate supplementation and high muscle glycogen stores have been shown to improve athletic performance, particularly in prolonged events where muscle glycogen becomes depleted. CHO ingestion has also been shown to improve performance in shorter duration, higher intensity tasks. Despite its lack of effect on muscle glycogen stores (1), recent studies have investigated the effect of a “central effect” via CHO mouth rinsing experiments to resolve this paradox. Oral receptors activated by the presence of CHO in the mouth may send signals that relay a positive response to the brain, potentially overriding negative affective signals that lead to a reduction in motor output (2). Recent studies have cited the activation of reward and motor control regions of the brain after oral ingestion of CHO (3). However, the main purpose of this study was to determine time to completion (TTC) differences in placebo vs. CHO mouth rinses, particularly in the glycogen depleted state. No statistically significant difference was found in TTC between CHO and placebo mouth rinses in either condition. This is in contrast with previous findings (2) (5). Yet, an increase in effort over the last 6k with the CHO mouth rinse may have been observed. Possible support for this conclusion arises from the statistically significant difference in heart rate observed between CHO and placebo conditions at the end of the time trials. Despite the lack of significant findings in most variables between the CHO and mouth rinse conditions, this study provided valuable insight into a possible mechanism for performance enhancement. TTCs were an average of 20 seconds faster in CHO than placebo. At elite levels of endurance competition, small time differences can provide notable advantages.

Methods
Subjects
5 endurance trained men (Table 1) participated after signing an informed consent form approved by the Texas Christian University IRB. The study followed a two-factor repeated-measures, randomized design (Fig. 1). Subjects completed the VO2 max test on the Velotron cycle ergometer before undergoing a glucose depletion bout, in which subjects cycled 50 minutes at 70% of VO2 max, followed by 6x1 minute sprints at 120% of VO2 max. For the next 24 hours, participants followed either a high CHO (75%) or low CHO (3%) diet. After this period, each subject completed a 3x6k time trial. During the time trial, participants ingested either 25 mL of CHO (4% maltodextrin) or placebo solutions for 10 seconds every 6k. Each trial consisted of a 2 day protocol. The first day was a glucose depletion bout, in which subjects cycled 50 minutes at 70% of VO2 max, followed by 6x1 minute sprints at 120% of VO2 max. For the next 24 hours, participants followed either a high CHO (75%) or low CHO (3%) diet. After this period, each subject completed a 3x6k time trial. Participants ingested either 25 mL of CHO (4% maltodextrin) or placebo solutions for 10 seconds every 6k. MEASUREMENTS
Metabolic data, heart rate and RPE were collected every 15 minutes during the depletion bout. Macronutrients for the 24 hour dietary control period were tracked with MyFitnessPal. Blood glucose was collected pre and post 3x6k time trial. During the 3x6k time trial, metabolic data was collected at 3k, 6k, 9k, 15k, 21k, and 27k. Heart rate and RPE were collected every 6k. The Boller Review, 2018

Conclusions & Applications
Due to the limited sample size, a lack of complete control over extraneous influences (diet, sleep, stress, etc.) further investigation on the potential mechanisms of the central effect and how it can be used to improve exercise and sport performance is warranted to provide valuable insight on the mechanisms of the central effect.