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# Effects of Rooibos Tea, Bottled Water, and a Carbohydrate Beverage on Blood and Urinary Measures of Hydration After Acute Dehydration

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**ORIGINAL RESEARCH**

# Effects of Rooibos Tea, Bottled Water, and a Carbohydrate Beverage on Blood and Urinary Measures of Hydration After Acute Dehydration

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*Rooibos tea contains polyphenol antioxidants, including flavonoids and phenolic acids that are potent free radical scavengers and has purported benefits for accelerated rehydration. The objective was to evaluate the effects of three different drinks (rooibos tea, bottled water, and a carbohydrate beverage) on blood and urinary markers of hydration after acute dehydration in collegiate wrestlers. Twenty-three athletes were recruited and followed a randomized, cross-over design with three different study arms comparing the effectiveness of rooibos tea, carbohydrate beverage (6% or 60 grams $l^{-1}$), or bottled water (placebo) in promoting rehydration after a 3% reduction in body mass. Urine specific gravity ($U_{sg}$) urine ($U_{osm}$) and plasma osmolarity ($P_{osm}$), and plasma volume were measured pre- and post dehydration and at 1-h after rehydration. Statistical analyses utilized a 3 (conditions) × 3 (times) repeated measures*

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*analysis of variance to test main effects. Significant interaction effects were found for $P_{osm}$ and $U_{osm}$, both of which remained below basleline after 1-h rehydration in the rooibos tea and water trials. No significant interaction effects were found for either urine $U_{sg}$ or plasma volume shift. The findings of this study demonstrate that rooibos tea was no more effective in promoting rehydration than plain water, with significant changes being found for $P_{osm}$ and $U_{osm}$ in the carbohydrate/electrolyte solution, in collegiate wrestlers after a 3% reduction in body mass and a rehydration period of 1-h when consuming 100% of their body weight loss.*

*KEYWORDS fluid balance, electrolyte balance, rehydration, euhydration, plasma omolarity*



## INTRODUCTION

Water is an essential chemical substance for all known forms of life. Water plays a pivotal role in many of the metabolic processes within the body, such as anabolism and catabolism. In proportion to water, electrolyte balance is also an important factor for good health, in that sodium (Na) and potassium (K) are necessary for the physiologic functions such as the transmission of nerve impulses and contraction of muscle. Physical activity and heat stress cause both fluid and electrolyte imbalances that must be corrected dietarily to maintain normal physiological function (Montain, Maughan, and Sawka 1996). Body temperature regulation (core and skin), during physical activity, depends on several environmental factors such as temperature, humidity, wind exposure, clothing worn, and by intrinsic factors such as gender, age, diet, and physiological stress. It is suggested that athletes rehydrate at a rate that closely matches sweat loss during exercise in order to prevent excessive dehydration (Coyle 2004; Sawka et al. 2007). Moreover, consumption of electrolyte-containing beverages is also needed to prevent changes in electrolyte balance that may lead to the impairment of physiologic function. Thus, in daily exercisers, restoration of the body water and electrolyte balance after exercise is an important task that permits the athletes to start the next exercise session in a hydrated state. Therefore, appropriate rehydration strategies before, during, and after exercise are recommended for optimal performance (Sawka et al. 2007).

Various commercial rehydration drinks differ with respect to composition and palatability and represent a multitude of strategies for improving postexercise rehydration. For instance, Nose, Mack, Shi et al. (1988) showed that plain water ingestion after exercise restored plasma osmolality at the cost of plasma sodium concentration and stimulation of urine production. Alternatively, the addition of sodium chloride to plain water increases fluid intake while reducing urine output (Nose, Mack, Shi et al. 1988). Many previous studies have demonstrated that, even if fluid intake is adequate, when the electrolyte concentrations are low there is an increase in urinary excretion and, consequently, the subjects are in negative fluid balance (Aragón-Vargas and Madriz-Dávila 2000; Maughan and Leiper 1993; Shirreffs and Maughan 1998). In addition, previous research indicates the importance of the inclusion of sodium in rehydration beverages (Maughan and Leiper 1995; Shirreffs and Maughan, 1996; Wemple, Morocco, and Mack 1997). Therefore, it currently is held that both the volume and electrolyte composition of fluid ingested should be considered in the postexercise rehydration recovery process. Due to the variable nature of sweat rates and sweat sodium concentration among individuals, it becomes increasingly difficult to prescribe an ideal drink formulation for all individuals. There has been a paucity of research on the effects of different beverages in promoting effective rehydration during the 1-hr period between weigh-in and competition in the sport of wrestling. Moreover, complete rehydration practice is not always practical, especially in discontinuous sports, such as wrestling and power lifting, where the interval between exercise sessions is inadequate for complete rehydration or when maintaining the initial body weight is an issue (Coyle 2004).

The effects of different rehydration protocols and fluid concentration in the replacement of fluid and electrolyte deficit has been thoroughly studied (Casa, Maresh, Armstrong et al. 2000; González-Alonso, Heaps, and Coyle 1992; Kovacs et al. 2002; Shirreffs et al. 2007; Shirreffs and Maughan 1998; Wong et al. 1998), whereas few studies are available on the effects of different beverages in promoting rehydration in wrestlers (Finn, Dolengert, and Williams 2004). In addition, there is limited research comparing different commercially available drinks in the dehydration/rehydration process in either athletic or nonathletic populations (Saat et al. 2002; Shirreffs et al. 2007).

Reddrox (Reddrox Inc., Eagle, Idaho) drink is a beverage derived from the indigenous red bush of South Africa's Western Cape (rooibos or red tea; Erickson 2003). Rooibos tea has a total polyphenol content of 60–80 mg per 150–250 ml serving compared with 128–199 mg found in 200 ml of black tea (Erickson 2003; Hakim et al. 2001), and it is also caffeine-free. Laboratory studies have evaluated the potential health benefits of rooibos in vitro and in vivo (Inanami et al. 1995; Komatsu et al. 1994; Kunishiro, Tai, & Yamamoto 2001; Nakano et al. 1997; Sasaki et al. 1993). There is also anecdotal information that when used as a fluid-replacement beverage, Reddrox provides minerals and electrolytes (Erickson 2003). Indeed, the product already is in use by some professional athletes for nutrition/rehydration purposes, although product efficacy has yet to be proven. To our knowledge, there are currently no data available regarding the effectiveness of rooibos tea in promoting rehydration in human subjects.

Therefore, the purpose of this study was to evaluate the effects of three different drinks (rooibos tea, bottled water, and a carbohydrate beverage) on blood and urinary markers of hydration after acute dehydration in collegiate wrestlers.

## METHODS

### Subjects

Twenty-three healthy male, National Collegiate Athletic Association (NCAA) Division I collegiate wrestlers participated in the study. Subject characteristics were as follows (mean ± SEM); age 19.6 ± 0.3 years, height 1.75 ± 0.02 m, and body weight (BW) 81.0 ± 3.4 kg, body fat (BF) 14.3 ± 1.3 %, and 9.4 ± 0.8 yrs. of wrestling experience. Before participation, all subjects provided written informed consent, and the experimental procedures were approved by the Institutional Review Board for investigations involving human subjects at Appalachian State University.

### Study Design and Protocol

The experiment followed a randomized, cross-over design with three different study arms comparing the effectiveness of rooibos tea, regular bottled water, or carbohydrate (6% or 60 grams $l^{-1}$) in promoting rehydration as measured by urine specific gravity ($U_{sg}$), urine ($U_{osm}$) and plasma osmolarity ($P_{osm}$), and plasma volume. Subjects reported to the Appalachian State University Human Performance Laboratory for orientation and three subsequent occasions for each trial, separated by at least a week. Subjects were instructed to report to the laboratory in a euhydrated state, which was confirmed through blood and urinary measures. During the first appointment, subject demographic data (height, BW, and body composition) were obtained; subsequently urinary and blood samples were collected. Body composition was assessed from a three-site skinfold test using a Lange skinfold caliper (Cambridge Scientific Industries, Inc., Cambridge, MA). Body density ($D_b$) was determined from the three skinfold measures using the prediction equation $D_b$ = [1.0982 – (sum skinfolds) * 0.000815] + [(sum skinfolds)$^2$ * 0.00000084] validated by Lohman (1981). Percent body fat (%BF) was determined from $D_b$ using the Brozek equation (Brozek et al. 1963). Each urine sample was collected in an inert polypropylene container. The $U_{sg}$ measurements were determined by an optical refractometer (NSG Precision Cells Inc., Farmingdale, NY). Each participant was provided a minimum weight loss goal of a 3% reduction in body mass. A 3% decrease in body mass was chosen because this represents the typical amount of dehydration that occurs in the sport of wrestling in the 24-h period prior to competition (Oppliger et al. 2006). Controlled acute dehydration was achieved during a 2-h standard wrestling practice regime that normally occurs during the competitive season. We have employed this dehydration paradigm in previous published studies

(Utter et al. 2003). After successful completion of dehydration, a second measure of BW, $U_{sg}$, $U_{osm}$, $P_{osm}$, and plasma volume were administered. During the 1-h rehydration period subjects were instructed to consume rooibos tea, carbohydrate beverage (6%, or 60 grams $l^{-1}$), or regular bottled water. A 1-h rehydration schedule was selected to simulate the time allowed between the official weigh-ins and the start of competition in both collegiate and high school wrestling. Research assistants provided all beverages to the subjects. During the first 5–10 min of the rehydration period, subjects consumed a beverage equal to one-half of their BW loss. From 20–25 min of recovery, subjects consumed a second volume of beverage to replace 100% of their BW loss. The third and final blood and urine samples were obtained at 60 min. A total of three blood samples were obtained during each trial, from the median cubital vein, on the anterior forearm via certified phlebotomists. $U_{osm}$ and $P_{osm}$ were determined via freezing point depression with an osmometer (Model 3250, Advanced Instruments, Inc., Norwood, MA). Plasma volume changes were estimated from hemoglobin and hematocrit values using the method of Dill and Costill (1974).

## STATISTICAL ANALYSIS

Values are expressed as mean ± SEM. Dependent variables were analyzed using a 3 (conditions) × 3 (times of measurement) repeated measures ANOVA. When Box's M suggested that the assumptions necessary for the univariate approach were not tenable, a multivariate approach to repeated measures ANOVA was used. In the latter case, the Pillais trace statistic was employed as the test statistic. Significant main effects were evaluated with paired *t* tests using a Bonferroni adjustment, with statistical significance set at $P < 0.025$.

## RESULTS

Subjects' preexercise body mass were statistically similar for all trials (rooibos tea 80.3 ± 16.1 kg, bottled water 79.7 ± 15.5 kg, and carbohydrate 80.1 ± 16.1 kg) as was the magnitude of body mass reduction in response to exercise ( 2.5 ± 0.15 kg). The mean reduction in body mass over all trials was 3.1 ± 0.19% from preexercise body mass. There were no differences in body weight regain among trials after the 1-h rehydration period ($P = 0.106$).

A significant interaction effect was found for $P_{osm}$ [$F(4,80) = 10.84$, $P < 0.01$]; see Figure 1. Post-hoc analysis of the interaction indicated that $P_{osm}$ was significantly different ($P<0.01$) between all three conditions at the 1-h time point. $P_{osm}$ remained lower than basline in the rooibos tea and water conditions after 1-h rehydration (Figure 1). A significant interaction effect also was found for $U_{osm}$ [$F(4,80) = 6.05$, $P < 0.01$]; see Figure 2. *Post-hoc* analysis of the interaction indicated that $U_{osm}$ was significantly different ($P < 0.01$) between all three conditions at the 1-h time point with $U_{osm}$ in the carbohydrate condition remaining significantly elevated when compared with the two other condition.

No significant interaction effects were found for either urine specific gravity or plasma volume shift. A significant time effect was found for $U_{sg}$

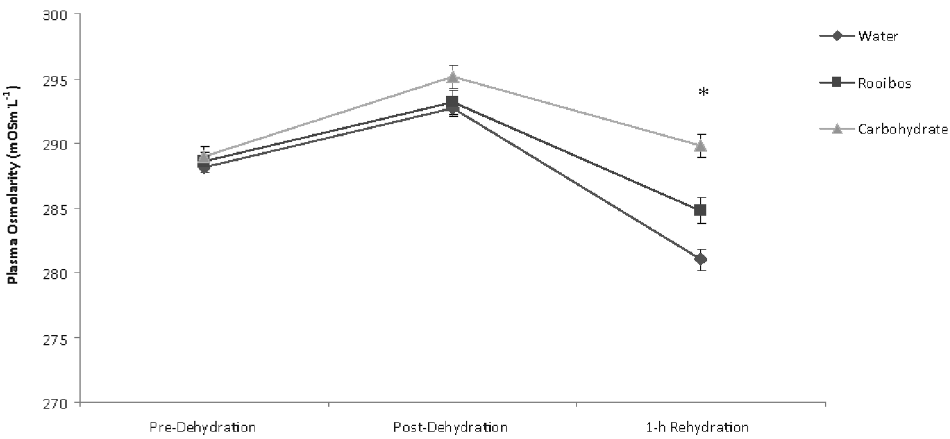


**FIGURE 1** Changes in plasma osmolarity over the course of the experiment. *All three time points were significantly different ($P < 0.01$) from one another at 1-h rehydration. Values are means ± SEM.

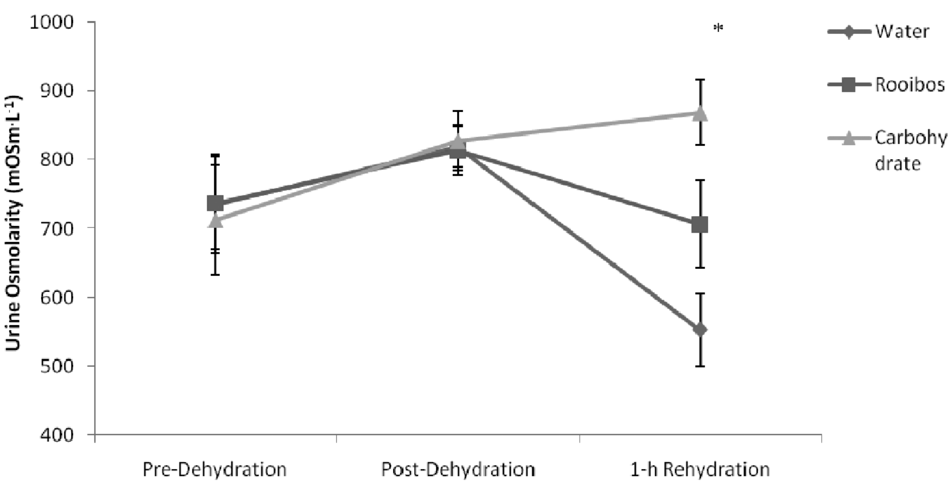


**FIGURE 2** Changes in urine osmolarity over the course of the experiment. *All three time points were significantly different ($P<0.01$) from one another at 1-h rehydration. Values are means ± SEM.

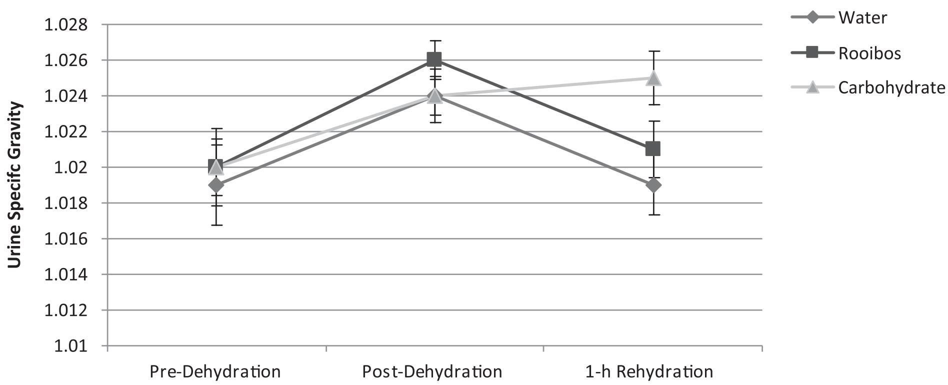


**FIGURE 3** Urine specific gravity over time between the three conditions. Main effects were time ($P < 0.001$) and condition × time interaction ($P = 0.084$). Values are means ± SEM.

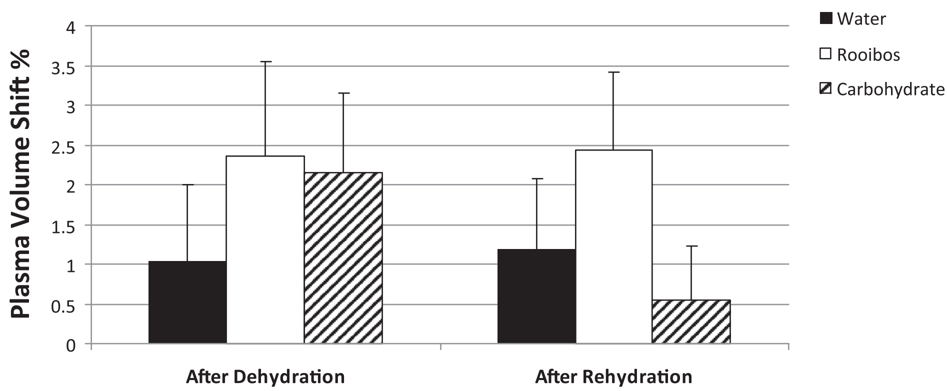


**FIGURE 4** Plasma volume shift after dehydration and 1-h rehydration periods. Main effects were time ($P = 0.324$) and condition × time interaction ($P = 0.214$). Values are means ± SEM.

[$F(2,44) = 9.40$, $P < 0.001$]; see Figure 3 but not plasma volume shift ($P = 0.324$); see Figure 4. In the carbohydrate trial $U_{sg}$ remained significantly elevated ($P < 0.01$) after 1-h rehydration, while both the rooibos tea and water conditions returned to baseline.

## DISCUSSION

In the current study, we evaluated the effectiveness of rooibos tea, bottled water, and a carbohydrate beverage in restoring fluid balance after acute dehydration in collegiate wrestlers (mean reduction of 3% preexercise body mass). In the United States, more than 250.000 high school and collegiate athletes participate in the sport of wrestling (National Federation of State

High School Associations 2002). In this sport, athletes compete in a dehydrated state for two reasons. First, some athletes undergo intentional dehydration to allow them to compete at a lighter weight with the strategic result of gaining a theoretical competitive weight advantage over their opponent. Second, wrestling tournaments require participation in multiple matches within a single day or on successive days with multiple weigh-ins. Therefore, the rest interval between wrestling matches could be inadequate for complete rehydration, and multiple-day weigh-ins may force the athlete to compete in a dehydrated state.

Results of the present study demonstrated that after consuming a volume of fluid equal to 100% of the body fluid loss during exercise, $P_{osm}$ in the rooibos tea and water trials were significantly lower at the 1-h time point when compared with the carbohydrate beverage and also significantly lower when compared with baseline ($p < 0.001$). This finding is consistent with a recent study completed by Shirreffs and colleagues (2007), who examined the effectiveness of four beverages (carbohydrate, Apfelschorle, and Evian and San Benedetto mineral waters) in restoring fluid and electrolyte balance after a 1.94% ± 0.17% reduction in body mass. In that study it was reported that after the 1-h rehydration period (time 0), $P_{osm}$ was significantly higher in carbohydrate trial when compared with the Evian and San Benedetto water trials ($p < 0.005$). In the present study $P_{osm}$ did not fall below baseline, but it returned to baseline, after the 1-h rehydration period in the carbohydrate trial. In contrast to our findings, however, Shirreffs and colleagues (2007) found that $P_{osm}$ still was elevated (294 ± 6 mosmol/kg) after the 1-h rehydration period in the carbohydrate trial. Differences between the studies could be explained in part by the initial amounts of body mass reduction, volume of the rehydration beverage consumed, and different recovery times. Senay (1979) suggests that a state of euhydration is associated with a $P_{osm}$ of 280–290 mOsm $L^{-1}$.

While no significant interactions were reported in the present study for plasma volume, there was a trend for plasma volume to be restored to baseline levels in the carbohydrate trial. As a trend, this finding is consistent with that of Shirreffs et al. (2007), who found that plasma volume was recovered to greater levels at 1 h after rehydration in the carbohydrate trial, whereas in the Evian and San Benedetto water trials this was achieved 3 h later. Previous studies have demonstrated the importance of glucose-electrolyte beverages in the recovery of plasma volume when compared with plain water (Nose et al. 1988; Shirreffs and Maughan 1998). Given that the rooibos tea consists of only trace amount of sodium and potassium (0.268 mmol·$l^{-1}$ and 0.183 mmol·$l^{-1}$, respectively, 200 ml of rooibos tea, respectively) the nonsignificant changes in plasma volume recovery are not surprising.

A significant interaction effect was found for $U_{osm}$, indicating that $U_{osm}$ was significantly different ($P < 0.01$) between all three conditions at the 1-h time point, with $U_{osm}$ in the carbohydrate condition remaining significantly elevated. This same trend was found for $U_{sg}$; however, the interaction was not statistically significant. Popowski and Colleagues (2001) found that both $U_{osm}$ and $U_{sg}$ lagged behind $P_{osm}$ in accurately identifying changes in hydration state produced by progressive acute dehydration after rehydrating with water. In the current study, this lag was reported only in the carbohydrate condition and not in the rooibos tea or water trials. A significant time effect was found for $U_{sg}$, which was demonstrated by an increase in $U_{sg}$ from baseline after the 3% reduction in body mass. This finding is consistent with that of Popowski et al. (2001) and reinforces its practical use to identify hydration status in both athletic (Farber et al. 1987; Francesconi et al. 1987) and clinical (Ballauff et al. 1991) populations.

In the current study, we chose a 1-h rehydration schedule to simulate the time allowed between the official weigh-ins and the start of competition in both collegiate and high school wrestling. While body mass was restored to baseline values at the end of the 1-h rehydration period in all three trials, a limitation of the present study was that there was no measure of fluid balance or urine volume. Nose et al. (1988) has demonstrated that plain-water ingestion after exercise results in a fall of $P_{osm}$ and sodium concentration, which stimulates urine production and reduces the stimulus to drink; both will lead to a delay in the rehydration process. The addition of sodium chloride (77 $mmol \cdot l^{-1}$) to water will promote an increase in consumption while reducing urine output. Shirreffs et al. (2007) and others (Maughn and Leiper 1995; Wemple et al. 1997) suggest that the amount of fluid retained is directly related to a drink's sodium concentration. While $P_{osm}$ returned to baseline in the current study after a 1-h rehydration period in all three conditions, it is likely that urine production may have been greater if obtained immediately after the 1-h rehydration period in both the rooibos tea or water trials because of its low sodium and potassium concentration. As such, we do not therefore interpret the finding that indicate that even though $P_{osm}$ returned to below baseline in both the rooibos tea or water trials, euhydration was reestablished.

The present investigation is the first to examine the effectiveness of rooibos tea in promoting rehydration in human subjects. Anecdotal information suggests that the product Reddrox (rooibos tea) is already in use by some professional athletes for nutrition/rehydration purposes, although product efficacy for this intent has yet to be determined. Nutritional benefits of rooibos are linked to the findings of Bramati et al. 2002 and others who have reported that rooibos tea contains polyphenol antioxidants, including flavonoids and phenolic acids that are potent free radical scavengers, but, interestingly, contains no caffeine, no alkaloids, and low contents of tannins (Morton 1983; Nakano et al. 1997).

While rooibos contains minerals, their concentrations are too low to make the tea a meaningful dietary source of minerals for the average consumer. In fact, with the exception of fluoride and copper, the amounts of iron, potassium (0.183 $mmol \cdot l^{-1}$), sodium (0.268 $mmol \cdot l^{-1}$), calcium, and magnesium in a 200 ml serving of rooibos tea are all less than 1% of the U.S. recommended daily intake (RDI). Thus, the nutritional rationale for rooibos tea as a combined water/electrolyte rehydration beverage is not warranted. The findings of this study demonstrate that rooibos tea was no more effective in promoting rehydration than plain water, with significant changes being found for $P_{osm}$ and $U_{osm}$ in the carbohydrate/electrolyte solution, in collegiate wrestlers after a 3% reduction in body mass and a rehydration period of 1h when consuming 100% of their body weight loss.

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