

Oral Electrolytes Stimulate Water Drinking by Dehydrated Horses

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Orally administered electrolytes were effective in stimulating voluntary water intake by horses dehydrated by endurance exercise or furosemide administration. The amount of electrolytes administered in our studies (200–250 g) was well tolerated and was substantially greater than that provided in most commercial electrolyte pastes. Authors' address: Dept. of Large Animal Clinical Sciences, D-202 Veterinary Medical Center, Michigan State University, East Lansing, MI 48824-1314. © 1999 AAEP.

1. Introduction

Prolonged exercise, food and water deprivation and acute enterocolitis all produce substantial depletion of body fluid and electrolyte stores. Based on changes in body weight, Carlson¹ estimated sweat water loss to be about 10 l/h during endurance exercise and suggested that greater losses occur during competitions under conditions of high heat and humidity. Thus, a typical 50-mile endurance ride lasting 5 hours could result in fluid losses approaching 50 l (~10% of body weight). Similar fluid losses are often experienced by horses dehydrated by severe enterocolitis.² In both instances, fluid losses are partially replaced by water drinking, but a substantial loss of body fluid (3–5% of body weight) may persist despite free access to water. Because the major stimulus for thirst is an increase in plasma osmolality (or plasma sodium concentration), replacement of water without electrolytes leads to dilution of remaining body fluid electrolyte stores (manifested by mild to severe hyponatremia) and a lack of thirst. In humans, this phenomenon of

persisting weight loss in the absence of thirst has been termed involuntary dehydration.³

To avoid or minimize involuntary dehydration, human endurance athletes and patients suffering from diarrhea can force themselves to drink a variety of isotonic to hypotonic carbohydrate/electrolyte rehydration solutions. In horses, administration of large volumes of isotonic rehydration solutions via a nasogastric tube is also effective in limiting involuntary dehydration consequent to prolonged exercise or diarrhea.⁴⁻⁶ Unfortunately, forced drinking is not an option for dehydrated horses, and frequent nasogastric intubation may not be acceptable (during endurance exercise) or well tolerated by all horses with diarrhea. In an attempt to stimulate drinking and replace electrolytes lost in sweat, endurance riders routinely supplement horses with oral electrolyte pastes before, during and after the ride. Similarly, oral electrolytes are sometimes used as an adjunct treatment with intravenous fluids in horses with diarrhea. Whether this practice ameliorates electrolyte losses, enhances voluntary water intake,

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or has adverse effects on intestinal absorption has received little study.

We recently completed a series of studies designed to determine whether oral electrolyte supplementation ameliorates fluid and electrolyte losses induced by endurance exercise or furosemide administration. In the first study, administration of oral electrolytes was effective in attenuating weight loss by increasing voluntary water intake during a 60-km simulated endurance ride on a treadmill.^{7,8} In the second study, recovery from furosemide-induced dehydration was enhanced by oral administration of electrolytes, and NaCl was found to be more effective than KCl.⁹ In both studies, the amount of electrolytes administered (200–250 g) was considerably greater than that available in most commercially available electrolyte pastes.¹⁰

2. Materials and Methods

A. Study 1

To determine whether supplementation with oral electrolytes (at doses estimated to replace electrolyte losses in 20–25 l of sweat) is an effective practice in endurance horses, weight loss, voluntary water intake, plasma osmolality and plasma protein and electrolyte concentrations were measured in six Arabian horses before, during, and after a treadmill exercise test stimulating a 60-km endurance ride. The horses were studied twice: with (E) and without (C) electrolyte supplementation. The supplement consisted of a 2:1 mix of NaCl and KCl salts and was administered as a slurry in a 60-ml syringe. ~250 g (~6 oz) of electrolytes was administered before and during the exercise test.

B. Study 2

To determine whether supplementation with oral electrolytes would improve rehydration of horses dehydrated by furosemide administration and overnight withholding of water and whether the composition of the electrolytes would further influence the rehydration process, body weight, voluntary water intake, plasma osmolality and plasma protein and electrolyte concentrations were measured in six horses every 6 hours for 36 hours after administration of oral electrolytes. The horses were studied after supplementation, in a randomized fashion and in the same manner as in Study 1, with NaCl (200 g), KCl (200 g) and a mixture of NaCl and KCl (100 g of each salt) and without supplementation.

In both studies, changes in measured parameters were examined by a two-way repeated-measures analysis of variance assessing effects of supplementation and time. When significant ($p < 0.05$) effects were found, a Student-Newman-Keuls test was performed to examine for specific differences between supplements and timepoints.

3. Results

A. Study 1

Weight loss after completion of the 60-km simulated endurance ride was greater ($p < 0.01$) in C (3.2%) than in E (1.0%) and was associated ($r = -0.85$, $p < 0.0001$) with less ($p < 0.01$) water intake in C (12.2 l) than in E (23.5 l). Plasma osmolality increased to a greater extent ($p < 0.01$) with E and was unchanged with C. In contrast, plasma protein concentration decreased ($p < 0.01$) in the later stages of the simulated ride with E, reflecting plasma volume expansion, but remained unchanged with C. Plasma Na^+ and Cl^- concentrations increased ($p < 0.01$) with E and were greater ($p < 0.01$) than values for C during the second half of the 60-km simulated ride. Despite administration of large amounts of potassium with E, plasma K^+ concentration was decreased ($p < 0.01$) at the end of each rest break during the simulated ride and after 60 minutes of recovery. Adverse effects of oral electrolyte administration were not observed, and decreases in plasma protein concentration within 30 minutes after drinking suggested that intestinal absorption was well maintained during the simulated endurance ride.

B. Study 2

Furosemide administration and overnight withholding of water resulted in moderate dehydration (4–5% body weight loss). During the first 18 hours of the rehydration period, body weight recovery and voluntary water intake were greater ($p < 0.01$) after administration of NaCl (29.0 l) or a mix of NaCl and KCl (28.2 l) than after administration of KCl (23.8 l) or no electrolytes (15.6 l). Plasma osmolality remained unchanged with electrolyte supplementation but decreased ($p < 0.05$) without supplementation. Plasma protein concentration tended to decrease after administration of NaCl or a mix of NaCl and KCl (reflecting plasma volume expansion), compared with a tendency to remain increased after KCl administration (reflecting preferential rehydration of the intracellular fluid space). Although plasma electrolyte concentrations remained within normal reference ranges, sodium and potassium concentrations were greatest with NaCl and KCl supplementation, respectively. No adverse effects of oral electrolyte administration were observed.

4. Discussion

Exhausted endurance horses as well as those with acute enterocolitis may experience severe dehydration and depletion of body electrolyte stores. Body water losses in both conditions typically exceed 25 l (5% body weight loss) and more often approach 50 l (10% body weight loss). Na^+ , Cl^- and K^+ losses in 25 l of sweat probably exceed 2500, 3500, and 1000 mmol,¹¹ and a similar magnitude of electrolyte losses was recently reported for horses in the early stages of experimentally induced enterocolitis.² Re-

placement of these sweat electrolyte losses would require supplementation with ~150 g NaCl and ~75 g KCl during a ride, whereas treatment of more severe exhaustion or colitis often requires administration of 100 to 300 l of intravenous fluids.^{5,12}

Most commercially available electrolyte pastes contain less than 10 g of NaCl and KCl (combined amounts) and many contain predominantly carbohydrates and trace amounts of other minerals.¹⁰ To date, there are no data from controlled studies to support that horses performing endurance exercise benefit from supplementation with minerals such as calcium or magnesium. Thus, replacement Na⁺, Cl⁻ and K⁺, for which losses are 100-fold greater than those of Ca²⁺ or Mg²⁺, is of much greater importance in the amelioration of fluid and electrolyte losses consequent to endurance exercise.

The data collected in Study 1 clearly demonstrate that supplementation with large amounts of NaCl and KCl can be an effective means to enhance drinking during endurance exercise. More importantly, administration of oral electrolytes was well tolerated by exercising horses with one exception: oral administration of salt slurries discouraged hay eating for approximately 5 minutes in some horses. Although not directly assessed, intestinal water and electrolyte absorption appeared to be well maintained during the simulated endurance ride and led to plasma volume expansion in the later stages of exercise after administration of electrolytes. An additional observation in Study 1 was that the majority of water intake occurred as a single drinking episode at each rest break (within 30–60 s after cessation of exercise from a water bucket offered as soon as the treadmill was stopped). Thus, a practical recommendation would be to ensure water availability immediately after completion of each phase of endurance exercise. Similar to findings reported previously,¹³ no clinically apparent adverse effects were associated with unlimited water drinking during the early portion of the rest or postexercise periods. Furthermore, because horses usually only drank once at each rest break, this study provided no support for delaying or limiting water consumption by hot horses immediately after completion of an exercise bout.

In Study 2, effects of varying the composition of oral electrolytes were further investigated in horses dehydrated by furosemide administration. Because an increase in plasma Na⁺ concentration is an important trigger of thirst, it was not surprising to

find greater water intake and more rapid restoration of body weight loss with NaCl pastes than with KCl pastes. As in Study 1, adverse effects of administration of oral electrolytes were not apparent, and no change in fecal consistency was produced.

In conclusion, oral electrolyte supplementation improved water intake during endurance exercise. Similarly, oral electrolytes improved rehydration of furosemide-dehydrated horses, and the degree of rehydration was influenced by composition of the electrolytes administered.

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