Electrolytes for Sport Horses - Are They Needed?

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Over the past two decades the variety of sports drinks and electrolyte supplements marketed to support hydration in both human and equine athletes has expanded dramatically. However, it is generally acknowledged that little, if any, fluid replacement is needed for exercise bouts lasting 2 h or less. For exercise lasting several hours human endurance athletes have been encouraged to drink about 500 ml a couple of hours prior to exercise and small amounts (150–300 ml) of a sports drink containing both electrolytes and carbohydrate every 15–20 min during exercise in an attempt to limit dehydration from exceeding a 2% BW loss. This frequent fluid replacement is not driven by thirst but by a conscious effort to drink in the absence of thirst. Of interest, this trend toward "excessive" fluid replacement (drinking that is not driven by thirst) is not without controversy in human sports medicine as it has become clear that excessive drinking of water or hypotonic sports drinks is the cause of exercise-associated hyponatremia (EAH). EAH and EAH-associated encephalopathy, now recognized as the leading cause of death in human endurance athletes, is particularly a problem for slower athletes that exercise for a longer period and have a greater opportunity (more time) for excess fluid replacement. Thus, perhaps it is fortunate that "you can lead a horse to water, but you can't make it drink" because horses cannot be trained to drink in the absence of thirst.

Exercise scientists opposed to the recommendation for excessive drinking by human endurance athletes cite the fact that no data exist to demonstrate that dehydration > 2% BW loss negatively affects performance in endurance competitions or significantly increases the risk of development of medical problems during or after competition. In fact, a study of 767 successful Ironman triathletes found that athletes that lost the most BW actually finished faster.

Although electrolyte supplementation of horses competing in endurance events has become a common practice, it warrants emphasis that, similar to their human counterparts, convincing data to document that fluid and electrolyte depletion adversely affects performance is currently lacking in endurance horses. Further, despite the favorable clinical responses observed with use of intravenous fluids for treatment of horses that either are eliminated for metabolic disorders or develop medical problems after competition, no data currently exist to document that affected horses are any more dehydrated than successful horses. Despite a lack of supportive data, supplementation of endurance horses with oral electrolyte slurries before, during, and after competition is widely practiced and there is evidence to support that this practice could enhance recovery.

Investigations to date have largely addressed the question of whether or not supplemental electrolyte administration would increase voluntary water intake (drinking) by exercising horses. Horses completing a 60 km simulated endurance ride on a treadmill, with water offered at multiple points during the test were studied with and without electrolyte supplementation. When horses ran without electrolyte supplementation, they lost about 25 kg of fluid as sweat and replaced a little more than half of this loss by drinking ~ 13 l of water. However, when they ran with electrolyte supplementation (salts were given as a slurry dosed into the mouth before and during the run) the horses drank ~ 23 liters of water, replacing nearly all of the fluid lost in sweat. In addition, to "tricking" horses into drinking a greater total amount of water by giving electrolytes, supplementation also resulted in horses starting to drink earlier during the course of the endurance. In this study, horses were given an amount of electrolytes that would be expected to be lost in 25 liters of sweat (~ 175 g NaCl and 55 g KCl). This was a much larger dose than typically used by competitors; nevertheless, no adverse effects of supplementing with this large amount of electrolytes were observed, although urine Na^+ concentration increased after the exercise test in electrolyte supplemented horses.

Next, to determine if horses would drink salt water, horses were exercised for 30 or 45 km on a treadmill at a walk, trot and canter, again simulating endurance racing. However, unlike the prior experiment, further dehydration was induced by administration of furosemide (1 mg/kg, IV) 90 min before the exercise test and horses were not offered anything to drink until the end of exercise. At the end of the test, horses were randomly offered either water or two concentrations of salt water (0.45% and 0.9% NaCl solutions) for the initial 5 min of recovery (while still standing on the treadmill) and then further water intake was measured from 20–60 min of recovery with the horse washed off and placed free in a stall. The initial drink volume (10–12 L, containing 90–110 g of NaCl for the 0.9% solution) was similar with all fluids offered and was consistent with the capacity of the equine stomach. More importantly, the initial drink of salt water was followed by further drinking of ~ 4 L of water from 20–60 min of recovery. In contrast, when horses were initially offered plain water, they did not drink further during the initial hour of recovery despite the fact that they remained partially dehydrated. Because drinking is stimulated by an increase in plasma osmolality, an initial drink of water dilutes ECF Na^+ concentration and abolishes the drinking stimulus. In contrast, with an initial drink of salt water, ECF Na^+ concentration remains elevated and horses wanted to drink again when provided water only a few minutes later. Thus, an initial drink of salt water "tricked" the horses into drinking a greater total amount of fluid during the initial hour of recovery. In a subsequent study by the same group, temperature preference was investigated by offering horses an initial drink of 0.9% NaCl at 10, 20, or 30ºC, followed by water at the same temperatures in a stall from 20–60 min of recovery. When different temperatures of salt water were compared, horses drank the greatest amount, and took longer drinks, when it was 20ºC, near the temperature water comes out of a hose on a warm summer day.

To determine whether or not dehydrated horses would voluntarily drink solutions at tonicities exceeding that of plasma, horses were dehydrated by furosemide administration and overnight water deprivation (but not exercise) to induce a BW loss of 5% or more. Initial drinks of plain water, isotonic solution including 0.9% NaCl or 5% dextrose solution, or hypertonic solutions including 1.8% NaCl, 2.5% dextrose in 0.9% NaCl, or 5% dextrose in 0.9% NaCl were offered, in a randomized fashion. Horses drank similar amounts of water or the isotonic solutions with an initial drink of 8–12 liters, again approaching stomach capacity, while initial drink volume was reduced by 50% or more with all hypertonic solutions offered. Thus, when salt water is initially offered to horses, tonicity should not exceed that of plasma. In further support of limiting tonicity of replacement fluids to that of plasma, nasogastric administration of a hypertonic (628 mOsm/kg) rehydration solution to furosemide-dehydrated horses appeared to delay intestinal absorption, indirectly assessed as a further rise in plasma protein concentration during the initial 2 h after fluid administration, as compared to administration of water or an isotonic rehydration solution. A long-standing concern has been whether or not administration of hypertonic oral electrolyte slurries could have similar adverse effects on gastric emptying and intestinal absorption of electrolytes and water - this controversy remains unresolved. However, a critical point is that when these hypertonic slurries are used during endurance races, riders must pay attention to ensure that their horses continue to drink after the electrolytes are administered. If drinking ceases, no further electrolytes should be administered and a horse that stops drinking is likely at risk for metabolic elimination.

In theory, greater intake of water and electrolytes, either by oral administration of hypertonic electrolyte slurries followed by voluntary drinking or by initially offering salt water, followed by plain water, should limit dehydration and enhance recovery. However, it again warrants mention that limited data exist to support that limiting dehydration either lessens the risk of metabolic elimination or development of medical problems following ride completion. An early study in Australia found higher plasma protein concentrations at both the ride finish and after 30 min of recovery in horses with heart rates > 60/min, as compared to horses with heart rates < 60/min. The investigators concluded that horses with higher heart rates were more dehydrated, yet BW loss was not measured. A recent report of 30 horses receiving veterinary treatment after metabolic elimination also described higher plasma protein and lower serum electrolyte concentrations in "pulled" horses, as compared to successful competitors but again BW loss was not measured. Recently, investigators in Australia also reported higher plasma protein and lower serum electrolyte concentrations at the mid-ride checkpoint in horses that were subsequently eliminated for metabolic problems in a 160 km race, as compared to successful horses or horses subsequently eliminated for lameness. Although the findings of these studies could support greater dehydration and electrolyte losses as risk factors for subsequent metabolic elimination, BW loss at the mid-ride in the latter study was not different (actually tended to be less) in horses eliminated for metabolic problems, again when compared to successful horses or horses subsequently eliminated for lameness. It is important to recognize that increases in plasma protein concentration and heart rate only support a decrease in effective circulating blood volume. The latter can decrease with either dehydration or a fluid shift; for example, fluid movement into the intestinal tract in the early stages of ileus or, arguably, with repeated oral administration of hypertonic electrolyte slurries. All in all, these studies again support the fact that our current knowledge of why some horses develop metabolic problems during endurance racing is limited.

What also remains unclear in horses is whether or not electrolyte supplementation can improve performance. To investigate the effects of electrolyte supplementation on performance, ride times were compared in a group of endurance horses that received oral slurries containing the amounts of NaCl and KCl expected to be lost in 30 liters of sweat (high dose) or expected to be lost in 10 liters of sweat (low dose) during an 80 km ride. There was no difference in ride completion times or other subjective performance factors assessed in horses that were given the higher dose of electrolytes; however, the study was limited because it was performed in non-elite horses competing in 80 km rides under moderate ambient conditions. Further, some of the horses administered the high dose of electrolytes developed serum Na^+ and Cl^- concentrations exceeding 150 and 115 mmol/L, respectively. Although no adverse consequences were observed, these high values suggest that the high dose may have provided more electrolytes than were needed by these horses. Recent work also demonstrated that nasogastric administration of a rehydration solution following treadmill endurance exercise enhanced the rate of glycogen resynthesis. This novel finding provides further support that electrolyte administration may enhance recovery and warrants study under actual race conditions.

PRACTICAL RECOMMENDATIONS FOR ELECTROLYTE SUPPLEMENTATION

A forage-based diet should provide an adequate source of potassium and, therefore, the main concern should be for salt (NaCl) replenishment during training and competition. Most commercial feeds do not provide adequate Na and Cl for horses that lose substantial sweat during training. For this reason, it is generally recommended to provide loose salt to horses in hard training - either added to feed or provided in a separate vessel.

A simple approach for endurance horses in regular training would be to add 1 volumetric ounce of NaCl powder (1 oz ≈ 30 ml of NaCl powder ≈ 35 g of NaCl because the bulk density of NaCl powder is ~1.15 g/cm^3, as compared to the absolute NaCl density of 2.165 g/cm^3) to the concentrate feed once or twice daily (depending on the amount of training and sweating). During times of the year when it is hot and more humid, the amount could be doubled to 2 oz in concentrate meals twice a day. Any excess that is not needed to replace losses would be excreted in urine and a simple test to assess adequacy of supplementation would be to measure urine Na^+ concentration in a morning urine sample collected before the concentrate meal is fed. Adequate supplementation should result in a urine Na^+ concentration > 30 mmol/L while a value < 20 mmol/L would indicate that more salt could be provided. A value > 100 mmol/L would indicate excessive supplementation and the amount being fed could be decreased in half. At present, there is no recommendation for supplementation with additional potassium, calcium, or magnesium as adequate amounts of these minerals should be available through the feed.

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If additional electrolytes are going to be administered during competition as oral electrolyte slurries or by offering salt water as an initial drink, these practices should be started during training to familiarize the horse with this type of supplementation and to ensure that it does not cause possible problems. Usually, oral electrolyte slurries are a mixture of NaCl and KCl powders (at a 3:1 ratio) and about 1 oz is administered with each dose (mixed in corn oil, applesauce or yogurt). For a 2 h training ride, one dose could be administered 1–2 h before the ride and an additional dose could be administered after 60–90 min of work. Horses should then be provided opportunities to drink while on the trail. Horses appear to have variable responses to oral electrolyte supplementation and if administering slurries before and during the training exercise bout does not result in an appreciable increase in voluntary water intake, this form of electrolyte supplementation during competition may not be advisable. An alternative approach in this situation could be to offer an initial drink of 0.9% NaCl at the end of the workout, always followed by plain water. Further, if electrolytes are administered in this fashion, there may be no need for further supplementation in concentrate meals.

During competition in 160-km endurance races with four veterinary checkpoints, administration of 1 oz of a 3:1 NaCl/KCl mixture at each checkpoint, in addition to 2 oz in a meal before the ride start provides about 150 g of NaCl and 60 g of KCl, an amount that would be lost in ~20 liters of sweat. Assuming that horses may lose 50 liters of sweat during the ride, this would replace about 40% of estimated losses and would seem a reasonable goal as 10 or more liters can also be replaced by absorption of water and electrolytes from the intestinal reservoir, leading to a net deficit of ~ 20 liters at the end of the ride. The goal is not to replace all sweat electrolyte losses during the competition and attempts to do so may result in undesirable hypernatremia and hyperchloremia.

Practically, oral electrolyte slurries are commonly administered at the end of the rest period at veterinary checkpoints because they can have a bad taste and stop the horse from eating at the checkpoint and they can also be irritating to oral membranes. When administered in this fashion, it is important that riders stop along the trail to allow horses to drink as well allow them to drink as soon as they enter then next checkpoint. Other alternatives that can be used to avoid this problem are to train horses to initially drink an isotonic NaCl/KCl solution (4 liters would approximate one dose of an oral slurry) or to provide the additional electrolytes in a mix of concentrate feed at the checkpoints.

What remains unclear is whether or not horses can be administered "too much electrolytes" and whether or not there truly can be adverse effects of electrolyte supplementation. In theory, excess electrolyte administration should not be a problem as long as competing horses are provided frequent access to water and continue to drink because excessive electrolytes should be excreted in urine. However, when electrolytes were administered in a high dose to fully replace anticipated sweat losses in an 80 km ride, mild hypernatremia and hyperchloremia developed in some horses. Although no clinical problems were observed with these electrolyte changes, this finding provides support to recommend limiting electrolyte replacement to 30–40% of the anticipated losses. Again, another 20% of anticipated losses may be replaced by intestinal reserves resulting in an overall deficit of 40–50%, approximating a 4–5% BW loss. Finally, whether or not supplementation with hypertonic oral electrolyte slurries may exacerbate gastric ulcer disease is another concern. A recent gastroscopic survey of high-level endurance horses found ulcers in 93% of horses during the competitive season as compared to only 48% during the short rest period between seasons. To assess whether or not electrolyte supplementation could possibly exacerbate gastric ulcer disease, groups of non-exercised horses were administered either eight doses of hypertonic oral salt slurries or a placebo (water) at hourly intervals. In comparison to gastroscopic findings 24 h before treatments were started, blinded scores for both number and severity of gastric ulcers were increased on gastroscopic examination 12 h after the last dose of electrolytes or placebo in both groups. However, scores for the horses treated with oral electrolyte slurries increased to a greater extent that for the horses administered the placebo. It would certainly be of interest to repeat this type of study in a group of endurance horses completing a 160 km race.

Our discussion of electrolyte supplementation so far has been limited to additional NaCl during training or a mix of NaCl and KCl during competition. The large amount of K^+ lost in sweat would support that supplementation with both NaCl and KCl is warranted during prolonged endurance exercise. Many commercially available electrolyte supplements also contain calcium and magnesium salts as well as varying amounts of carbohydrate (glucose and others). Although 8–10 g of calcium and 4–5 g of magnesium may be lost in 50 liters of sweat, no research to date has specifically investigated whether supplementation with these minerals is of benefit. Of interest, when a mixture of NaCl and KCl were administered to horses completing a 60 km treadmill endurance exercise test, the mild decrease in ionized calcium concentration and mild increase in venous blood pH observed during control (non-supplemented) runs were abolished with NaCl and KCl supplementation alone.

So, what's the bottom line? The bottom line is that horses exercising for more than a couple of hours in hot, humid climes (especially when combined with transport) will likely benefit (and voluntarily drink more water) when they are supplemented with extra NaCl and KCl. An easy recipe for hard working horses in the summer would be 1–2 oz of an equal mix of table salt and lite salt added to the grain twice daily. Next, an initial drink of salt water during the first few minutes after exercise (or at rest stops during the exercise bout) is another strategy that may be useful on especially hot and humid days. Salt water (0.9% NaCl) can be easily made by adding one ounce of table salt for each gallon of water. However, because horses can be finicky about drinking, you should always offer plain water after initially offering salt water. In reality, the goal should be to replace only about 30–40% of the electrolytes lost in sweat as the horses can also draw on the electrolyte reserves in the large intestine during and after exercise. Finally, have them keep the ice in their own cooler if there is access to a hose. However, if the water becomes warm (like bath water) after sitting in the sun all day, owners should share some of the ice with their horses.

For the client full of questions about electrolyte supplementation, have them take a close look at the contents of the electrolyte supplements on the shelf the next time they go to the feed mill or tack shop. They should try to determine out how much of each product would be needed to replace the electrolytes lost during a good workout (1–2 hours) of trotting and cantering on a hot, humid day: about 10 kg of sweat containing as much as 75 g of NaCl and 30 g of KCl (have them take a calculator). They will likely find that many of the products contain more sugar than electrolytes, yet we still don't know if horses really need this sugar as much as human athletes do. Finally, have them compare the cost of giving these supplements to replace the 10 kg sweat electrolyte loss to the cost of 75 g of NaCl and 30 g of KCl (equal to about 1.5 oz of table salt [NaCl and 2 oz of lite salt [½ NaCl and ½ KCl] that they can purchase at the grocery store). I expect that they will find the comparison a bit surprising.

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