Comparison of SmartLytes® and Hydration Hay™ for Performance Horses in the summer

B. L. Green

Texas A&M University-Commerce

School of Agriculture

25 May 2016

Abstract

Dehydration in horses can lead to muscle fatigue resulting from electrolyte losses. This is a great concern to owners, particularly in the summer when increased temperatures can lead to increased water loss through sweat. In order to prevent significant water loses, a product such as Hydration Hay™ (HH, Purina Animal Nutrition LLC) may be used to "hyperhydrate" the horses prior to intense exercise in the heat. Another possible treatment to prevent dehydration is the use of the electrolyte supplement, Smartlytes® (SL, SmartPak Equine, Plymouth, MA, USA), to prevent and restore electrolyte concentrations lost in sweat. The purpose of this study was to evaluate and compare the effectiveness of the SmartLytes® supplements and Hydration Hay™ in combating the effects of water loss. To complete this study, 6 mature horses were divided into three groups of two: the control group with no dietary change, HH group supplemented with 0.91 kg of HH soaked in 5 L of water, and SL group given 30g of SL per day. All horses were given ad libitum access to the pasture. To compare the treatments in each horse, vital signs and blood samples were taken before and after 30 minutes of exercise in an uncovered arena. Blood electrolyte concentrations were measured using StanBio Liquicolor Test Kits. All results were an analyzed using the MIXED procedure of SAS. Treatment did not affect ($P \geq 0.05$) rectal temperature, respiration rate, heart rate, or packed cell volume. Likewise, there were no treatment effects for blood concentrations of chloride or sodium. From these results, it cannot be shown that either HH or SL were able to successfully maintain hydration status during exercise in the summer.

Introduction

Electrolyte deficiency is commonly associated with decreased performance. The imbalance is often a result of dehydration, particularly in the summer when increased temperatures can cause large amounts of sweating during exercise (Maughan and Lindinger, 1995). Losses of electrolytes may lead to fatigue and muscle weakness. Significant deficiencies in electrolytes can result in muscular dysfunction and impaired temperature regulation. The loss of muscle function may not only cause decreased performance in horses but can also lead to serious injury, and the inability to regulate temperature could cause death from heat stroke (Duren, 1998).

To prevent detrimental electrolyte losses, many owners have begun using electrolyte supplement to counteract electrolyte loss through sweat. Supplements work by providing additional electrolytes to replace the ones lost during exercise and several studies have shown that supplements may be a viable option to increase water intake prior to exercise and maintain electrolyte concentrations during strenuous activity (Coenen et al., 1995; Schott II et al., 1999; Lindinger and Ecker, 2013). This study will focus on chlorine and sodium concentrations as these nutrients are vital to equine performance and are most easily lost through sweat (Duran, 1998). Because severe electrolyte losses are so closely associated with dehydration, closely monitoring their concentrations throughout extensive exercise can provide information on the level of hydration.

Another method of preventing decreased performance as a result of dehydration is through hyperhydration, or increasing water intake prior to exercise. Purina's product, Hydration Hay (HH) does this by providing the horse with an additional 5 quarts of water when

consumed. The purpose of this study is to determine if these methods maintains hydration status in horses that have been exercised in high temperatures.

Literature Review

Electrolytes are salt ions within the body that help cells maintain the voltage across the cell membrane. They play a vital role in maintaining muscle activity, osmotic pressure, and fluid balance (Sherwood, 2001). Some of the most important electrolytes are chloride, magnesium, sodium, phosphorus, calcium and potassium. Of these, sodium, potassium and chloride are most easily lost during exercise through sweat, urine and feces (Duran, 1998). Sodium plays an important role in membrane action potential and skeletal muscle excitation (Sherwood, 2001) and it has been found that in horses, the concentration of sodium found in sweat increases as the rate of sweating increases (Warner and Mayhew, 1983). Additionally, sodium plays a large role in maintaining fluid homeostasis because it is a major determinant of osmolality (Brownlow and Hutchins, 1982). Therefore, monitoring the status of electrolyte concentrations is crucial for performance horses because it is among one of the most important factors limiting muscle performance in athletes (Goundasheva and Sabev, 2011).

A horse's requirements of these electrolytes depends largely on the amount of sweat that it produces (Meyer, 1987). An endurance horse may lose as much as 45 liters of fluid through sweat a day (Carlson and Ocen, 1979). Increased sweating that occurs due to vigorous exercise is a serious concern, particularly in the summer months where increased temperatures may further increase the amount of electrolytes lost through sweat. The reason that horses lose electrolytes so quickly through sweating is because, unlike humans, the sweat of horses is hypertonic instead of hypotonic, meaning it contains more electrolytes than plasma (Marcella, 2004). Large

deficiencies in electrolytes can cause muscular dysfunction, yet the bigger concern regarding the loss of fluid through sweat is the inability to regulate temperature, an impairment that often occurs as a result of severe dehydration (McCutcheon and Geor, 1998). Eventually, anhidrosis, or the inability to sweat normal amounts, may occur when dietary needs are not met combined with extended periods of sweating (Backhouse, 2000).

The environment in which horses are exercised contributes greatly to the expected changes in electrolyte concentrations (Carlson et al., 1974; Rose et al., 1977; Hall et al., 1978). In studies conducted in hot, humid climates electrolyte losses in the horses were much more severe than studies conducted in more mild summer temperatures (Carlson et al., 1974; Hall et al., 1978).

Although loss of water leading to dehydration is the primary cause of electrolyte deficiencies during exercise, it is important that horses being exercised are not simply given water to prevent dehydration. Plain water will not replace the electrolytes lost through sweat. In fact, giving a dehydrated horse water will also increase urine output, causing additional electrolyte loss, thus further contributing to dehydration (Lindinger and Ecker, 2013). In a study observing the restoration of electrolyte balance after endurance exercise, it was found that a glucose-electrolyte solution was better for recovering bodyweight after exercise than plain water, contributing to the idea that decreases in sodium concentrations lowers the urge to drink water. Additionally, consuming water increases urine output, which further increases the loss of bodyweight (Hyyppä et al., 1996).

A possible solution to this problem is to provide performance horses with an electrolyte supplement prior to intense exercise. Several studies suggest that offering these supplements is a viable method to prevent electrolyte losses from reaching a dangerous level. One study

completed by Schott II et al. (1999), showed that in horses given an electrolyte supplement before a 60 km endurance ride, sodium and chloride concentrations increased during the second half of the workout. A similar study by Lindinger and Ecker (2013) evaluated the effects of an electrolyte supplement known as Perform'N Win (Buckeye Nutrition, Dalton, OH, USA) versus plain water. In this test, horses were given either water or the electrolyte supplement and subjected to various treadmill exercises. This study found that horses given 3 liters of electrolytes supplement were not only able to maintain their quality of performance throughout the exercise but were also able to exercise for longer durations (Lindinger and Ecker, 2013).

In order to evaluate the electrolyte and hydration levels in horses, factors such as skin turgor and capillary refill time can be measured. Both tests can be used to identify dehydration. While skin turgor will be normal with mild dehydration, the turgor will decrease with moderate (6-9%) and severe (>9%) dehydration (Subudhi et al, 2005). Capillary refill test involves pressing a finger into the horses gums, which are normally moist and pink, and measuring how long it takes to return to its normal color. In a horse that is adequately hydrated, the color should return in two seconds or less. However, if it takes longer than two seconds to return to its original color, the horse may be suffering from dehydration (Emergency!, 2013). Because electrolyte deficiency is often associated with dehydration, performing tests to evaluate the horse's level of hydration can help determine whether a significant amount of electrolyte has been lost.

Objective:

This study aimed compare the effectiveness of SL and HH to regular water in their ability to successfully prevent water loss during exercise in high temperatures. In order to achieve this

goal, this study we monitored the effects of theses supplements on hydration status using packed cell volume and vital signs as well as the sodium and chloride concentrations of the blood before and after strenuous exercise in hot summer temperatures.

Methodology

Horses and Study Design

This project used 6 mature riding horses, 3 geldings and 3 mares of various breeds and ages randomly placed into three groups of two with a mean body weight of 525 ± 69 kg. All horses were housed with ad libitum access to pasture and were offered 0.91 kg of 14% CP pellet·horse^{-1}·day^{-1}. Horses were stratified by age and sex into three treatment groups in a latin square design. Treatment groups included control (no dietary change), Hydration Hay group (0.91 of HH soaked in 5 L of water), and Smartlytes group (30g of electrolyte supplement per day). The horses were separated and received their designated treatment for four mornings leading up to and including sampling days.

This study was conducted in August of 2014 in Northeast Texas because the severe temperatures are ideal for studying the effects of dehydration. On the fourth day of each week, the horses were ridden for approximately 30 minutes in the afternoon, during the hottest part of the day in an uncovered arena. The original design was to take the horses on a 2 hour trail ride, but due to the high temperatures, we opted to stay in the arena for the safety of the riders. The mean daily temperature was 37˚ C for Ride 1, and 37.8˚ C for Ride 2 and Ride 3. In order to reduce the effects of a small sample size, the groups were rotated throughout the project in a Latin Square design so that every horse eventually received each of the three possible treatments. After each series of treatments, horses were given a 3 day wash-out period in which they

received no treatments in order to ensure that the treatment supplements were flushed from their system before beginning the next treatment.

Collection of Physiological Data

The horses' body weights were recorded every day in order to monitor any changes as well as immediately before and after exercise. Additionally, heart rate (HR), rectal temperature (RT) and respiration rate (RR) were recorded the day of exercise both before and after each ride. These vital signs were compared to the normal value for horses as described in the Merck Veterinary Manual (Khan and Line, 2010) to help assess the rigor of exercise. Packed cell volume (PCV) was measured using blood samples collected directly before and after each ride in order to evaluate the level of hydration from pre-ride to post- ride.

Collection of Blood Samples

Blood samples were collected via jugular venipuncture using vacuum tubes for measurement of the horse's packed cell volume and electrolyte level using StanBio Liquicolor Test Kits before and after each ride. Blood samples collected for packed cell volume were analyzed directly following each ride. The remaining samples were taken to the lab were they were labeled, centrifuged and frozen until needed. The StanBio Liquicolor Tests were used to measure chloride and sodium levels in the blood. By comparing electrolyte levels, skin turgor, and capillary refill time before and after each trail ride, we hoped determine if HH and SL supplements are effective at reducing dehydration risk in horses.

Statistical Analysis

Data were analyzed using the MIXED procedure of SAS. The individual horse was the experimental unit. The main effect was the treatment, and the random effect were horses within each treatment sequence. Least squares means was calculated, and means different at the ($P <$

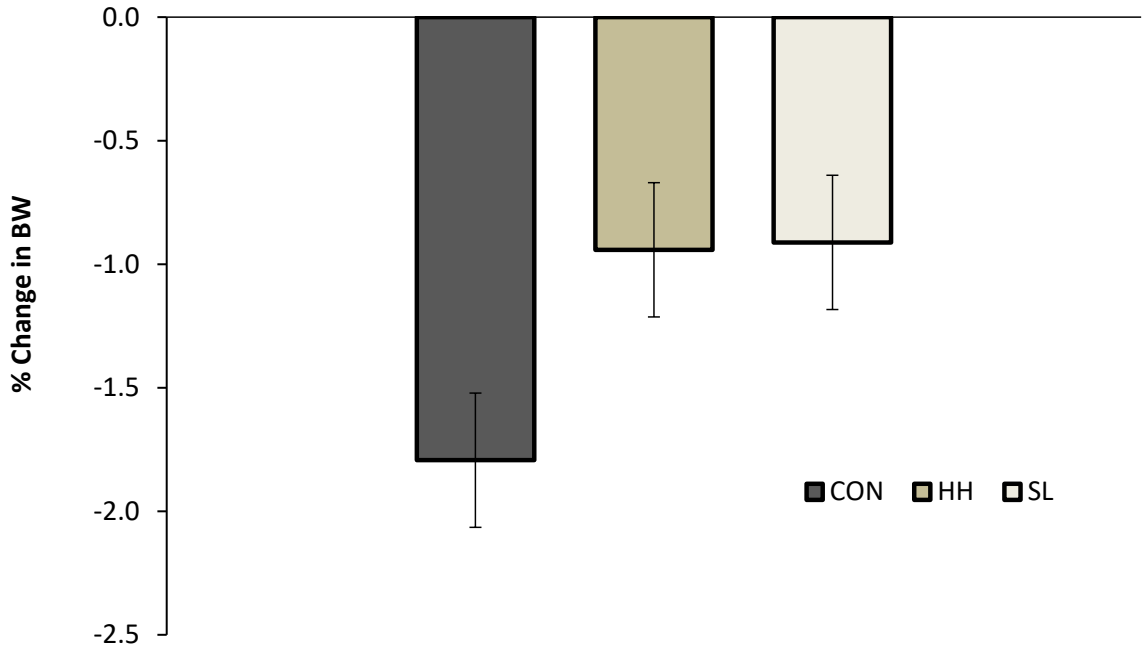
0.05) level was separated using pairwise comparisons. The independent variable is the specific treatment that each horse received and the dependent variable is the hydration status as indicated through the analysis of blood electrolyte concentrations, HR, RR, RT, and PCV.

Results

Change in Body Weight

The mean percent change in body weights across each treatment group is shown in Figure 1. There were no effects of treatment and no interactions between the main effects were observed (P = 0.36). The negative values for change in weight are significant in that they indicate that the horses were exercised to a point in which they were losing water weight through sweat.

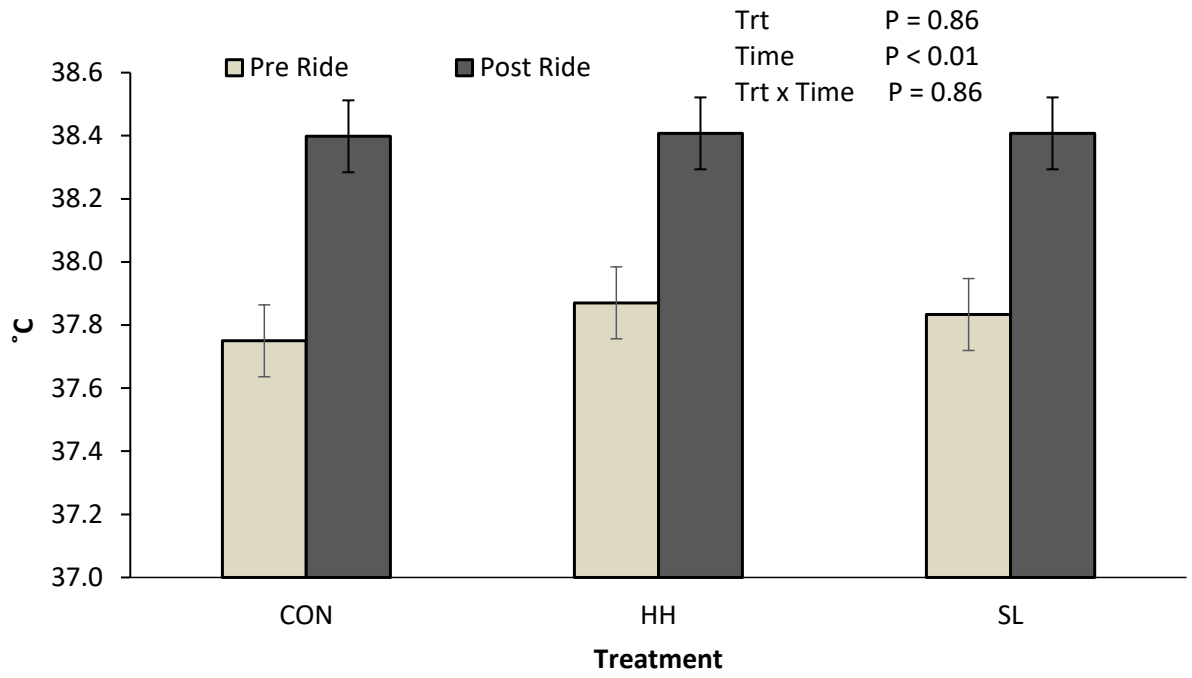
Figure 1. Average percent change in body weight across treatments from pre-ride to post-ride.



Rectal Temperature

The effect of all treatments from pre-ride to post-ride are shown in Figure 2. There were no effects of treatment (P = 0.86), however, there was a time effect from pre-ride to post-ride (P< 0.01). There was an increase in rectal temperature of 0.59˚ C across all treatments from pre-ride to post-ride indicating that exercise was rigorous enough to increase body temperature.

Figure 2. Effect of Hydration Hay™ (HH) and Smartlytes (SL) on the change in rectal temperature from pre-ride to post-ride while exercising in the summer.

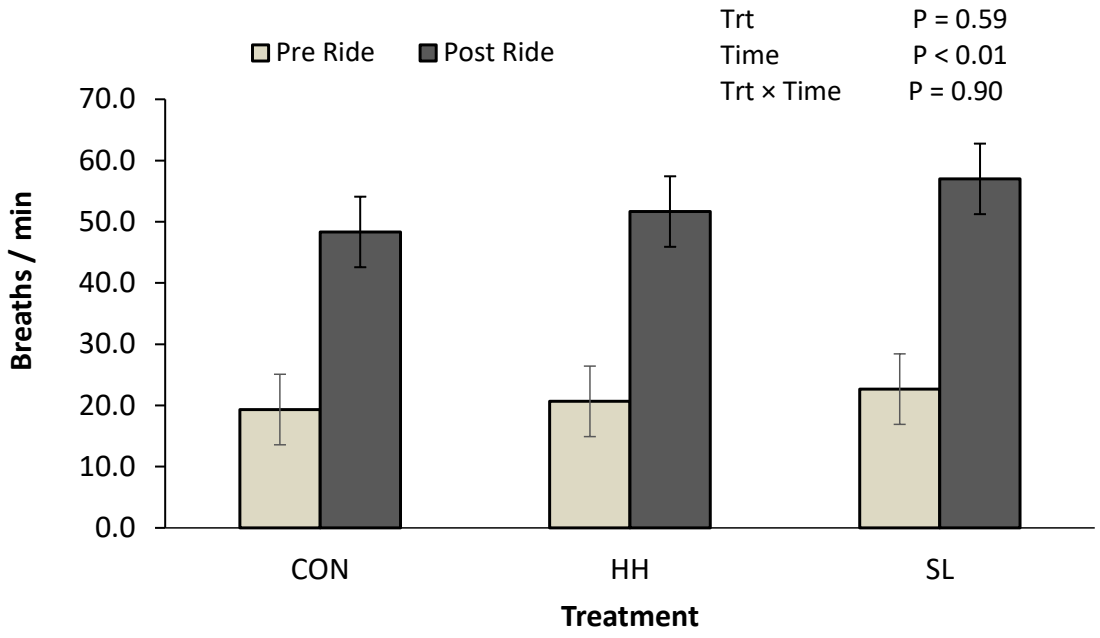


Respiration Rate

The effects of each treatment on respiration rate from pre-ride to post-ride is shown in Figure 3. The results showed no treatment effect (P = 0.59) however there is a time effect from pre-ride to post ride (P< 0.01) where respiration rate increased by 31 breaths per minute as a result of exercise. Although there is no treatment effect, the increase in respiration rate from pre-

ride to post-ride indicates that exercise was vigorous enough to cause the horses to breathe more rapidly.

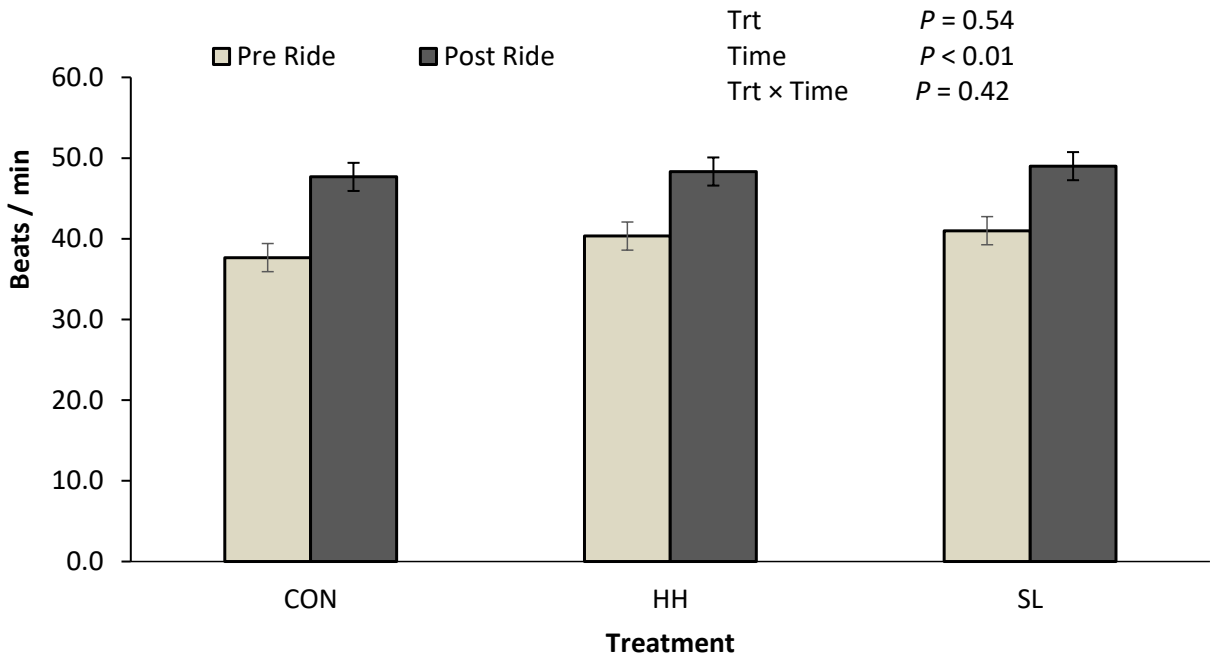
Figure 3. Effects of Hydration Hay™ (HH) and Smartlytes (SL) on the change in respiration rate of horses from pre-ride to post-ride when exercised in the summer.



Heart Rate

The effects of the treatments on heart rate from pre-ride to post-ride are shown in Figure 4. Once again, results indicate no treatment effect ($P = 0.54$) but there is a time effect ($P < 0.01$) where heart rate increased by 8.7 bpm from pre-ride to post-ride due to exercise. Although there was no treatment effect, the time effect indicates that the exercise was strenuous enough to cause an increase in heart rate.

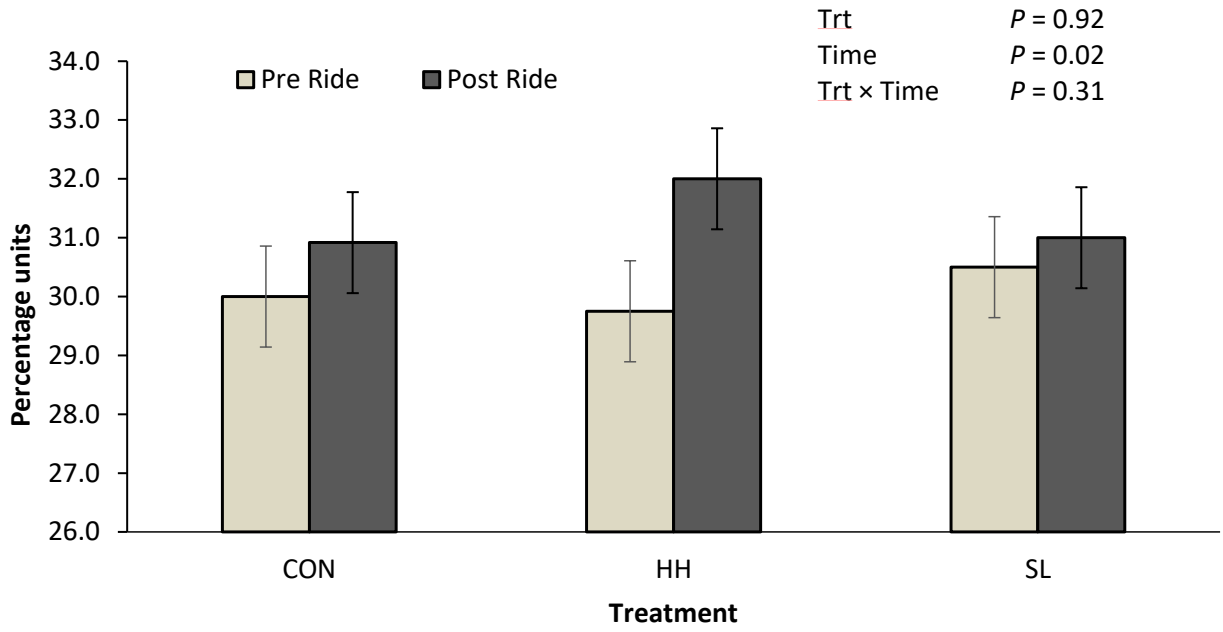
Figure 4. Effect of Hydration Hay™ (HH) and Smartlytes® (SL) on the change in heart rate of horses from pre- ride to post- ride when exercised in the summer.



Packed Cell Volume

The effects of each treatment on Packed Cell Volume from pre- ride to post- ride is shown in Figure 5. There is no effect across treatments ($P = 0.92$) nor a time affect for any group ($P = 0.02$). There was only a 1.2 percentage unit increase from pre- ride to post- ride for packed cell volume indicating only a small change in hydration status and no dehydration in the horses.

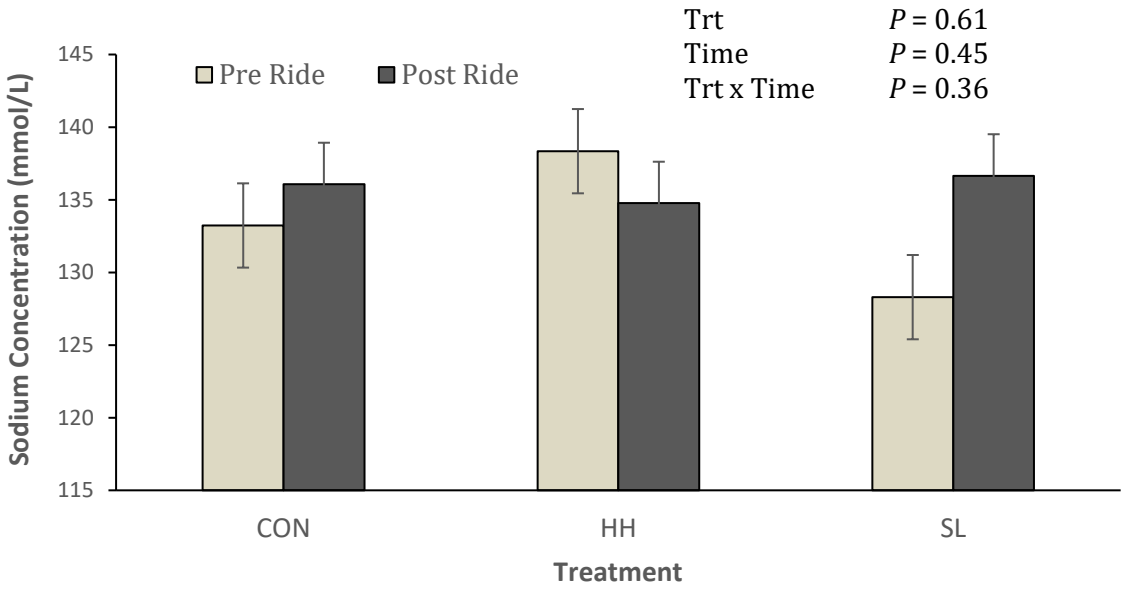
Figure 5. Effect of Hydration Hay™ (HH) and Smartlytes (SL) on packed cell volume from pre-ride to post- ride when exercised in the summer.



Blood Sodium Concentrations

The change in average blood concentrations of sodium from pre-ride to post-ride are shown in Figure 6. There was no treatment effect (P = 0.60) nor a time effect from pre – ride to post – ride (P = 0.45). Because sodium is easily lost through sweat and plays a large role in fluid homeostasis, these results may indicate that the horses did not sweat much or did not reach a severe level of dehydration. It may also be noted in the figure that although the average sodium concentrations for CON and SL increased from pre-ride to post-ride, the concentration decreased for the HH group.

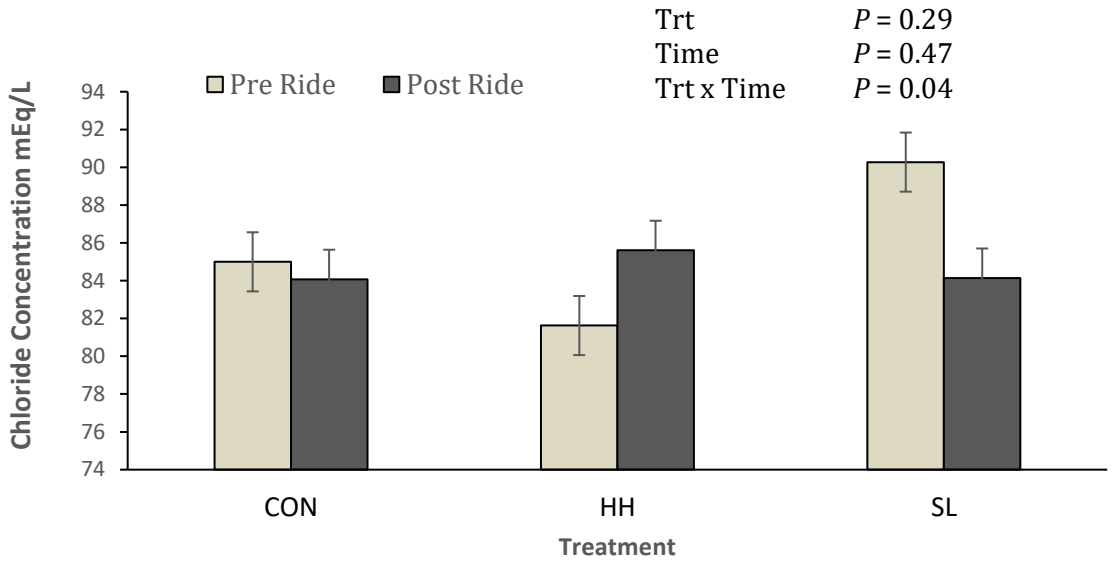
Figure 6. Effect of Hydration Hay™ (HH) and Smartlytes® (SL) on sodium concentrations from pre-ride to post-ride when exercised in the summer.



Blood Chloride Concentrations

The average change of blood chloride concentrations are displayed in Figure 7. There was no significant differences across treatments (P = 0.29) and no time effect (P = 0.47) from pre-ride to post-ride. Chloride is easily lost through sweat. Therefore, a minimal change in blood concentrations indicates the horses did not sweat much and were not severely dehydrated. It can also be noted that although the average blood chloride concentrations decreased over time from pre-ride to post-ride for CON and SL groups, the concentration increased for the HH group.

Figure 7. Effect of Hydration Hay™ (HH) and Smartlytes® (SL) on chloride concentrations from pre-ride to post-ride when exercised in the summer.



Discussion

None of the vital signs measured in this study detected a significant difference in hydration status as a result of any of the treatments. However, there were time effects for RT, RR, and HR. From these data, we cannot say that HH or SL maintained hydrations status, but the time effects for RT, RR, and HR indicate that the horses were indeed starting to feel the strain of exercise. Yet, there was no treatment nor time effect for PCV or blood concentration of chloride and sodium, and therefore dehydration was not achieved. It could be said that regardless of when samples were collected, there was no difference in the hydration status of horses treated with HH versus horses treated with SL.

It may also be noted that our "Pre-Ride" values for heart rate and respiration rate were at the top of the normal range for horses. According to the Merck Veterinary Manual (Khan and Line, 2010), the average resting heart rate for horses is 28-40 beats per minute and the resting respiration rate is 10-14 breaths per minute. The horses used in this study had an average resting

heart rate of 40 beats per minutes and respiration rates close to 21 breaths per minute prior to exercise. The reason that our values may be higher than normal could be error on the account of the person who recorded the values or it could have been due to the fact that these horses had not been used for most of the summer and were simply out of shape.

If given the opportunity, I would like to complete the study again, keeping the horses in stalls and using a more rigorous and consistent exercise regimen. The study deviated from the original plan in that we had intended on taking the horses on a two hour trail ride for exercise. Because the temperatures were so high, we opted to exercise them in the open arena close to the main barn for the safety of the riders instead. Although not a significant difference, we can see that sodium concentration in horses given HH decreased from Pre-Ride to Post-Ride, whereas these levels increased in horses treated with SL. In the blood chloride measurement, we can see that chloride concentrations increased from Pre-Ride to Post-Ride in horses given HH and decreased in horses treated with SL. Once again, these data are not significant but if tested again with more vigorous exercise, I would be interested to see if this trend continues.

As stated previously, a study done by Schott II et al. (1999), showed that horses given an electrolyte supplement before a 60 km endurance ride, had an increase in sodium and chloride concentrations during the second half their workout. It is possible that a longer endurance ride would have yielded results determining whether or not HH and SL can successfully maintain hydration status.

This study was unable to determine any significant difference between SL and HH. In order to determine whether these supplements can successfully prevent dehydration, more research will need to be done. In order to determine whether these products are a viable option

for preventing dehydration, the horses used will need to be pushed further so that the control group begins to show signs of dehydration.

Summary

Overall, body weight, HR, RR, RT, and PCV were not affected significantly by either treatment. However, there were significant time effects for all values except for PCV. Packed cell volume was not significantly changed from pre-ride to post-ride in SL, HH or the control group, indicating that the horses in this study never reached the point of dehydration. Blood concentrations of sodium and chloride did not change significantly across treatments, nor were they affected by time. Therefore, it cannot be said whether or not SL or HH helped to maintain hydration status. Further research is necessary in order to determine whether these supplements can adequately maintain hydration status during exercise in the summer.

Implications

From our research, it cannot be said whether Smartlytes® and Hydration Hay™ can successfully prevent dehydration in summer temperatures. A better understanding of the products currently offered to combat dehydration in increased temperatures can provide equine enthusiasts with the awareness necessary to prevent dehydration during exercise in the summer and give knowledge them as to which products are the best to achieve the desired result. Further research is necessary.

Personal Perspective

Working on this project has allowed me to develop many of the skills necessary to being a scientist as I enter the field of veterinary medicine. Working with Dr. Wahrmund, I learned how to create an experimental design and what things are important to consider when trying to create a test for my hypothesis. I also faced many common challenges that can occur when working with live animals. In a lab, it is much easier to control the environment, however, working with animals out in the field, it is sometimes impossible to predict situations that will arise. Additionally, I gained the valuable experiences of preparing an academic abstract and presentation and had the opportunity to present at a conference. Although my research yielded no significant data, I learned that even insignificant data can contribute to the understanding within a certain topic and I feel proud and accomplished for all of the things I learned throughout the process of conducting this study and writing my thesis.

Acknowledgements

This project would not have been possible without the excellent guidance and support of Dr. Jackie Wahrmund. I would also like to thank Dr. Bob Williams for helping me complete these final steps as well as Dr. Ray Green and Dr. Yvonne Villanueva-Russel for their continued support through this thesis process and throughout my time at Texas A&M University – Commerce.

Literature Cited

Backhouse, J. W. 2000. The implications of heat generation and electrolytes in feed and competition in athletic horses. Asian Australasian Journal of Animal Sciences. 13: 394-399.

Carlson, G. and P. Ocen. 1979. Composition of equine sweat following exercise in high environmental temperatures and in response to intravenous epinephrine administration. Journal of Equine Medicine and Surgery. 3: 27-32.

Coenen, M., H. Meyer, and B. Steinbrenner. 1995. Effects of NaCl supplementation before exercise on metabolism of water and electrolytes. Equine veterinary journal. 27:270-273.Coso, J.D., E. Estevez, R. Baquero, and R. Mora-Rodriguez. 2008. Anaerobic performance when rehydrating with water or commercially available sports drings during prolonged exercise in the heat. Applied Phisiology, Nutrition & Metabolism. 33: 290-298.

Duren, S. 2000. Feeding the Endurance Horse. Kentucky Equine Research. 2: 351-363.

Emergency!. 2013. http://www.horse-canada.com/magazine_articles/emergency/. Accessed April 10, 2015.

Goundasheva, D. and S. Sabev, 2011. Influence of exercise on acid-base, blood gas and electrolyte status in horses. Trakia Journal of Sciences. 9: 63-67.

Hyyppä, S., M. Saastamoinen, and A.R. Pösö, 1996. Restoration of water and electrolyte balance in horses after repeated exercise in hot and humid conditions. Equine Veterinary Journal. 28: 108-112.

Kahn CM, Line S. The Merck veterinary manual. Whitehouse Station, NJ: Merck; 2010.

Lindinger, M. I. and G.L. Ecker. 2013. Gastric emptying, intestinal absorption of electrolytes and

exercise performance in electrolyte-supplemented horses. Experimental Physiology. 98: 193-206.

Marcella, K. 2004. Sweating the small stuff. The Newsmagazine of Veterinary Medicine. 35: 8E-10E.

Maughan, R. J. and M.I. Lindinger. 1995. Preparing for and competing in the heat: the human perspective. Equine veterinary jounal. 27: 8-15.

Mayhew, I. G. and A. Warner. 1983. Equine anhidrosis: a review of pathophysiological mechanisms. Veterinary Research Communications. 6: 249-264.

McCutcheon, L. J. and R.J. Geor. 1998. Sweating. Fluid and ion losses and replacement. The Veterinary clinics of North America. Equine Practice. 14: 75-95.

Meyer, H. 1987. Nutrition of the equine athlete. Equine Exercise Physiology. 2: 644-673.

Rose, R. J. 1986. Endurance exercise in the horse – A review. Part I. British Veterinary Journal. 142.6: 532-541.

Schott II, H.C., K.F. DÜsterdieck, S.W. Eberhart, K.A. Woody, and M. Coenen. 1999. Electrolyteand glycerol supplementation improve water intake by horses performing a simulated 60 km endurance ride. Equine Veterinary Journal. 31: 418-424.

Sherwood, L. 2001. Human Physiology From Cells to Systems. 4th ed. Brooks/Cole, Pacific Grove, CA.

Subudhi, A. W., E. W. Askew, and M. J. Luetkemeier. 2005. Dehydration. In: B. Caballero, editor, Encyclopedia of human nutrition. 2nd ed. Elsevier, Oxford. p. 518-526.