Tevis Dehydration Study – Part 2

Dehydration and other factors affecting performance at the 2019 Tevis

by Jerry R. Gillespie, DVM, PhD, Principal Investigator

Originally published in Endurance News

In this article, I will discuss the interaction of dehydration with other variables affecting a horse's performance in a highly competitive endurance competition, like the Tevis. Figure 1, at right, shows the pattern of weight loss we found in horses during competition in the 2019 Tevis; large weight loss during the first approximately 50 miles, followed by a sustained level of body weight loss during the remainder of the competition (see Part 1). This body weight loss is due to loss of body water (see Part 1). This pattern of dehydration has been shown by us in other endurance rides and by other investigators.[1-6]

To better understand the impact of dehydration on horses' performance during endurance competition, we will examine other variables that affect performance of endurance horses. Taking these variables into account is necessary because most of these variables will impact the extent of the dehydration a horse experiences during competition, and presumably the impact of dehydration upon the performance and health of the horse.

Two examples of variables affecting hydration during competition: 1) a horse that is not familiar with the competition or has not had a chance to physiologically adapt to the conditions of the competition, will in all likelihood experience a higher level of dehydration, particularly during the early phases of the competition; 2) while it would be unusual, a rider who is focused on placing high in the competition may bypass watering opportunities for his/her horse in order to maintain their position in the competition. These would seriously compromise the horse's hydration status.

Here is a list of variables considered in this article:

Rider—multifactorial variable:

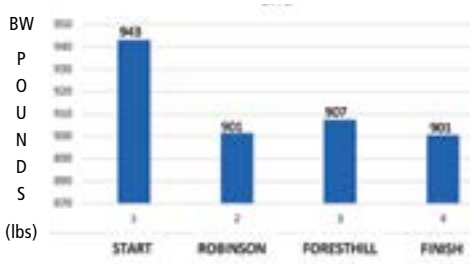
✔Talent as a rider—ability to ride effectively (balanced) and without becoming exhausted in a way that affects their concentration and riding

✔Ability/capacity to select a talented horse for the sport

✔Ability to make sound decisions during the competition; e.g., pacing

✔Ability to train, condition and manage the husbandry and the health of the horse

Figure 1. Group 2 body weights (BW) at each weigh site



✔Nutritional management before and during competitions

✔Relationship with their horse during competitions—in harmony with horse vs. fighting with horse. Includes: ability to ride in a way to preserve horse, to motivate horse to choose pace dictated by rider, and to care for horse during ride.

✔Health and emotional state during the competition

✔Motivation (factors not mutually exclusive—but require choices during competition). Motivated to: win, preserve horse's health, to finish (as a primary goal), to ride with others regardless of pace.

Horse—multifactorial variable:

✔Athletic genetic makeup—all those inherent structural and biochemical traits that favor athletic performance specific to a sport, e.g., endurance

✔Athletic development that enables the fullest expression of inherent athletic factors. Early environmental and nutritional impacts on development

✔Training—opportunity and capacity to learn and experience the sport

Figure 2. Theoretical normal distribution curves for athletic talent vs. number of horses in three populations: all athletic horses, sport horses, and endurance horses

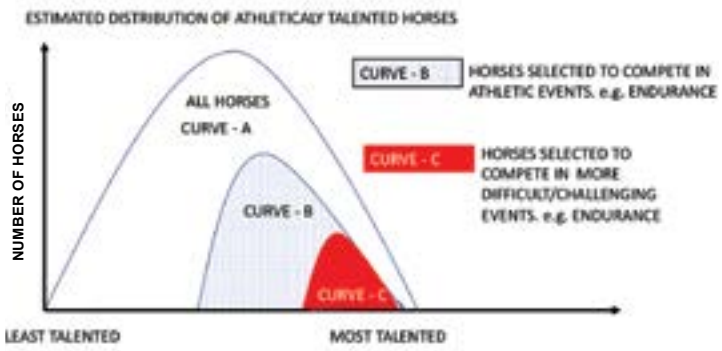


Table I. Performance Values from 2019 Tevis

Measure	Group	Values
Ratio of number of horses finished: Number of horses pulled	Finish/Start	98/183 (53%)
	Pulled/Start	85/183 (46%)
Completion Time	Top 10	16:37 (Sat. 9:27pm) to 17:29 (Sat. 10:29pm)
	Last 10	23:07 (Sun. 4:53am) to 24:00 (Sun. 5:00am)
Time difference between first horse and last horse to finish	7:23	
Ratio of horses that finished in the last hour: total number finished	# finished during last hour	52 (53%)
	Total # finished	98
Average speed of top ten vs. average speed of last ten finishers	Top 10	8.38 mph
	Last 10	5.4 mph (64%/top 10 ave. speed)

✔Aptitude and attitude toward the sport; i.e., how motivated is the horse to perform the specific athletic event (willingness to compete), including tolerating training, conditioning and the rider

✔Willingness to eat and drink appropriately during competition

✔Conditioning—how well does the horse respond to training that specifically enhances its ability to compete, e.g., in endurance

✔Physiological changes associated with transportation/competition dehydration conditions

✔Adaptation to all aspects of the sport: transportation, high temperatures/humidity, change in environments, response to various trail conditions, changing riders, being around large number of horses, vehicles and people, changes in food and water.

Trail and other environmental features of the competition: straight or very windy, surface of trail (e.g., rock vs. smooth), elevation changes, ambient temperature/humidity.

Other unforeseen or uncontrollable factors (e.g., good/bad fortune).

This list of variables is familiar to endurance riders as they are part of what they evaluate, nearly daily, when preparing their horses for competition. Most of these variables are factors that are in place before the competition begins, i.e., most cannot be substantially changed during the competition.

What isn't precisely known is the relative importance of these variables in any particular horse. If one lumps all the factors that influence performance of all athletic horses, it is likely all horses would fall somewhere within the confines of the "normal distribution curve" shown in figure 2, previous page.

The larger curve (Curve A) describes all the athletic horses in the world; ranging on the left side of the curve showing a small number of horses with little or no talent to perform to the very few and unique athletic horses on the right that are extraordinarily talented as athletes.

If we had precise numbers within the larger curve, we could show a curve describing all horses competing in endurance (Curve B) and finally a curve showing those horses selected for the more difficult/competitive rides like Tevis (Curve C). These curves are approximations, but likely show a general relationship between these groups of horses and the estimated expected number of high performing, average performing and poor performing horses in each group.

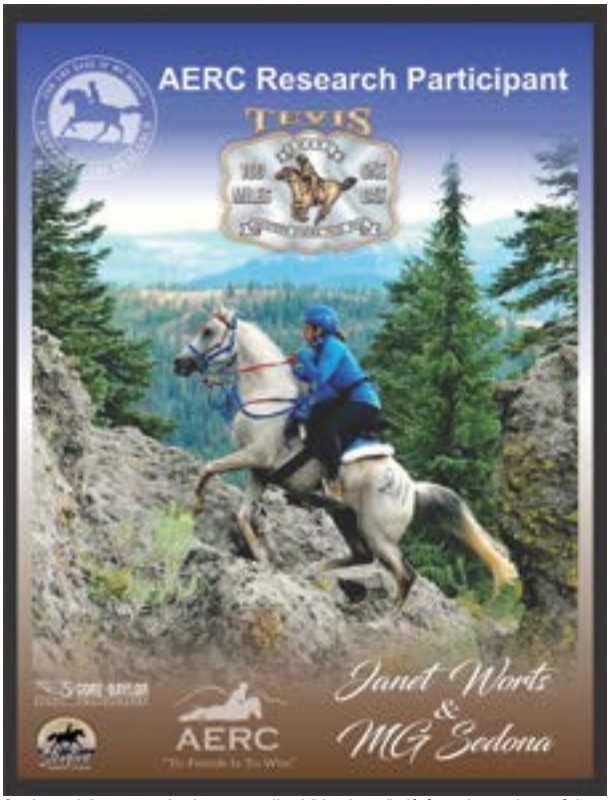
One of the points made by these normal distribution curves is that even in a select group of athletic horses in a sport like endurance, there is considerable variation in performance. This variability is more or less present in all endurance rides and is particularly evident at challenging rides like Tevis.

Table II. Number of pulled horses at points where horses were weighed and their percentage of weight loss at each weigh point compared to their starting weight

Weighting Site	Robinson Flat	Foresthill	Finish
Number pulled	15	17	6
# of pulled horses weighed	4	5	2
Percentage weight loss for each horse	1 – 5.4% (RO) 2 – 14.0% (Metabolic) 3 – 4.9% (Lame) 4 – 6.2% (RO)	1 – 7.1% (RO); 2 – 5.0% (RO); 3 - 7.6% (RO) 4 – 3.0% (Metabolic) 5 – 4.8% (Lame)	1 – 6.2% (Lame) 2 – 5.5% (Lame)
Average % weight loss of all horses weighed	4.4%	3.8%	4.5%

While "to finish is to win" is a laudable goal, particularly in a challenging endurance ride like the Tevis, in this article we will examine the difference in performance based upon horses placing in the 2019 Tevis and their segmental speeds.

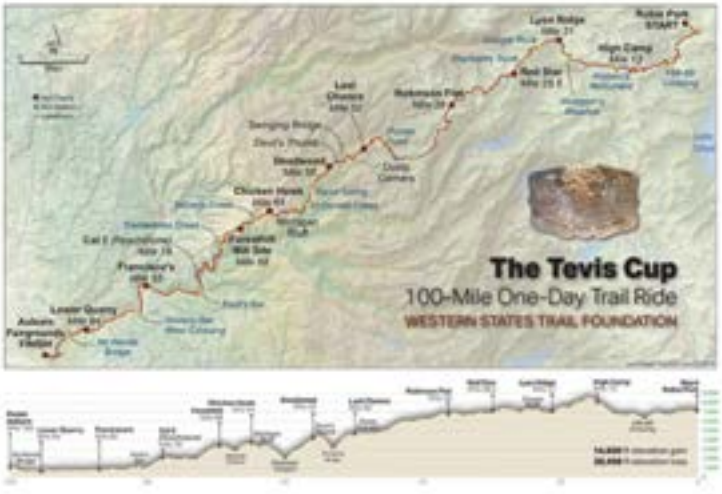
For analysis and discussion, we will describe "high performance" as high segmental speeds and high placing in the competition. We will show that there is not an even distribution of the number of high performing and poor performing (lesser-performing) horses in challenging endurance rides like the Tevis. In the 2019 Tevis, there is a smaller number of "high performing horses," and a larger number of horses on the lower side of the performance curve. This means that there will not be a normal distribution (bell-shaped) curve like that shown in curve A, Figure 2. Instead, excluding the horses that were pulled, the study shows that 20 horses fall in the top-performing group and 78 of the horses fall in the lower-performing group.



Study participants received a personalized "thank you" gift featuring a photo of them on the trail by Gore-Baylor Photography and design by Anne York.

Table I on the previous page shows evidence of the wide variability in performance at the 2019 Tevis. We begin with the percentage of horses pulled vs. those who completed the competition (See Table I, 53% completion in the 2019 Tevis). There are a variety of reasons for horses being pulled from the competition—lameness, metabolic disorders, accidents on the trail, riders opting to quit the competition because of their own well-being or that of their horse and others. While being pulled is not generally viewed as a "failure" on the part of the horse or rider, these pulls are part of the overall variables that can impact level of performance and must be included in a thorough examination of performance and magnitude of dehydration measured in individual or groups of horses in a ride.

Figure 3. The Tevis Cup trail map



We found, with the exception of one horse, that the horses pulled and weighed at Robinson Flat, Foresthill and the finish had greater percentage of weight loss at these points compared to their starting weights than the horses that continued in the competition beyond these points (see Table II on page 12). Here, we are comparing the percentage of body weight loss at each point in the ride to that at the start of the competition.

It is important to remember that we found that the level of dehydration in horses during competition is even greater if one compares the body water loss at each point in the ride compared to the horses' home stable weight (see April *EN*).

Figure 3 above shows the map of the Tevis trail, which will give the reader a reference for the measurements made in the studies at the 2019 Tevis.

Ride veterinarians and riders have recognized that there is a significant difference in the segmental speeds of the horses in the top 10 or top 20 compared to the rest of the horses in the competition. Our study may be the first to document this difference. To illustrate this point, in the 2019 Tevis 52% of finishers finished in last hour (23 to 24 hours competition time); 70% of finishers finished in last two hours (22 to 24 hours of competition time). This is illustrated in figure 4 on the previous page. This figure shows the speeds during different segments of the 2019 Tevis.

Figure 5. Segmental speeds of groups of 10 horses in 2019 Tevis

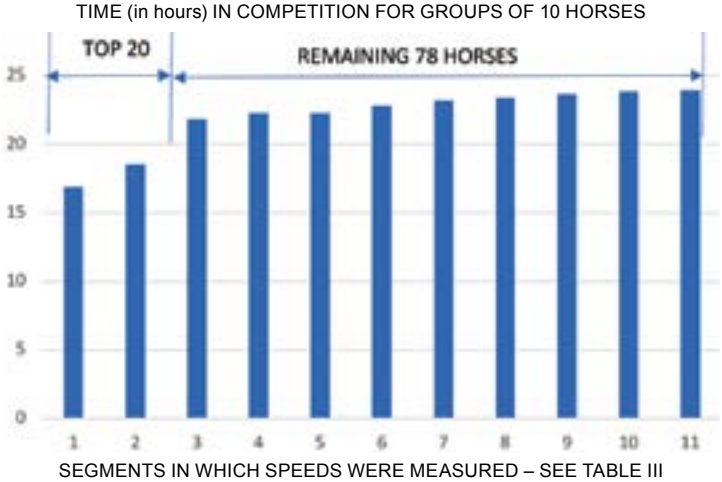
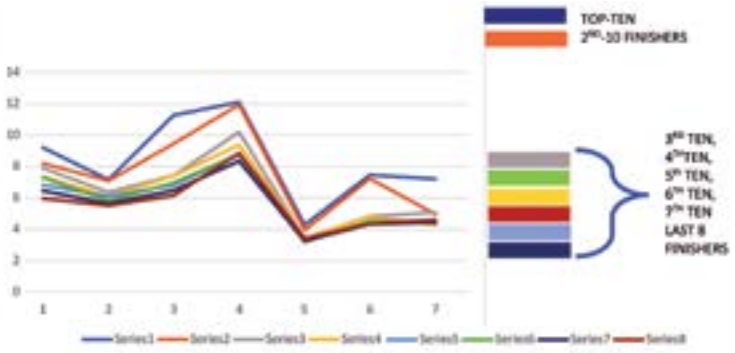


Figure 4. Segmental speeds of segments of the 2019 Tevis by groups of 10 riders (first to last 10)



See Table III for description of the segments illustrated in figure 3.

It is of interest that all groups follow the same speed profile throughout the Tevis, i.e., all horses went faster or slower over particular segments of the trail. We have found that the same general segmental speed profile was followed by the horses in the 2016 and 2018 Tevis competitions. This suggests the importance of the trail features' impact on pace of all horses, i.e., all horses slow during the more challenging part of the trail and speed up during "easier" sections of the trail.

Table III. Segments used to measure speed of horses in the 2019 Tevis and illustrated in Figure 4, above

Segment	Miles
1. Start to Hodgson's Cabin	18.5
2. Hodgson's Cabin to Red Star Ridge	10
3. Red Star Ridge to Robinson Flat	7.5
4. Robinson Flat to Last Chance	14
5. Last Chance to Foresthill	18
6. Foresthill to Francisco's	17
7. Francisco's to Finish	15

Figure 4 illustrates the greater segmental speeds of the top two groups (top 10 and second group of 10) compared to the remainder of the horses (groups 3 through 7, plus the last eight horses). The first horses set a faster pace than other groups throughout the competition. The last eight groups were bunched together at lesser speeds than the leaders during each segment.

Interestingly, the second-10th group slowed significantly during the final segment. One might speculate this occurred because it was clear they could not overtake those in the top 10. The separation in segmental speeds of the first two groups and the remainder is illustrated in a different way in figure 5, above, which shows each group's time in competition (on trail and in

Table IV. Changes in top ten at sequential checkpoints

MAKEUP OF TOP TEN AT SEQUENTIAL VET CHECKS

Location	# who remained in top ten from previous check	Pulls from top 10	# of new riders in top ten	Previous position of new riders
High Camp	—	0		
Robinson Flat	9	0	1	26th @ High Camp
Last Chance	8	0	2	12th @ Robinson 13th @ Robinson
Foresthill	6	2	4	11th, 12th, 14th & 17th @ Last Chance
Francisco's	10	0	0	
Finish		1	1	12th @ Francisco's

veterinary checkpoints).

What is the impact of the faster speed of the top 20 on dehydration? To explore this question, we will look at some factors that define these two groups throughout the competition. We identified the horses in the top 10 by their arrival at High Camp (13 miles from the start). We then looked at the makeup of the top 10 at all subsequent timing points (See Table IV, previous page).

In general, the rider makeup of the top 10 changed very little throughout the 2019 Tevis competition. Five horses remained in the top 10 at each checkpoint beginning at High Camp through the finish. Beginning at Foresthill, the same horses remained in the top 10 through the finish.

Tevis research logo designed by artist and AERC member Anne York of Starfire Design Studio, www.starfiredesignstudio.com.

With the one exception (the horse/rider team in 26th place at High Camp moved into the top 10 at Robinson Flat), the riders who replaced those who dropped out of the top 10 were in the second 10 at the prior checkpoint (see Table IV). For example, the four top 10 riders that dropped out at Foresthill were replaced by the 11th, 12th, 14th, and 17th riders at Last Chance, and this pattern was repeated at other checkpoints.

Throughout the ride the top 10 was made up of 18 different horses. During the ride only three out of these 18 horses were pulled (16% from this group), which is a substantially smaller percentage than the 46% pulled from the entire group of riders. These finding suggest that the top 10 horses are generally more capable at the sport, and are able to withstand the factors that lead to being pulled from competition compared to others.

All horses in the Tevis have a one-hour required hold time at two veterinary checkpoints (Robinson Flat and Foresthill). It is useful to look at the ratio of time-on-trail: time-in-hold for the two groups of horses (greater segmental speed group vs. lesser segmental speed group).

The top 20 group value for time-on-trail: time-in-hold is 7 and the same ratio for the remaining groups of horses is 11.5. In other words, the top 20 group spent much less time on the trail and therefor relatively more time in the vet checkpoints than the remainder of the horses.

This means that the top 20 horses had relatively more time to eat and drink in a more relaxed environment than the other horses in the competition. Another way to consider this is that the slower groups of horses spent more time on the trail without familiar feed than the faster horses.

The composition of the food in the gastrointestinal tract makes a substantial difference in the amount of water and electrolytes contributed by the gut to the exercising horse's body during the competition[7], i.e., intake of feeds like beet pulp and hay at vet checks along with water enhances the horse's hydration with absorption of water with electrolytes from the gut on the trail.

Four of the top 10 finishing horses did not weigh at any of the weigh sites; however, we collected weights on 15 of the top 20 horses. Because the top 10 and second 10 groups were close in their performance (segmental speeds and duration on trail), considering their weight changes together during the ride is informative. It is interesting that the average percentage weight loss, start to finish, in all the horses weighed was 5.5%, and the value for the top 20 weighed (14 horses) was 4.0%. This 1.5% difference is substantial, representing approximately seven liters of body fluid per horse difference in the groups.

Studies have shown that human[8] and equine[9,10] athletes with experience (adaptation) and conditioning in endurance exercise tolerate dehydration and perform better. In brief, conditioned horses will sweat greater amounts and more effectively cool their body, enabling higher athletic performance; at the same time, they will drink greater amounts of water during exercise.

These higher performing athletes will also have a higher cardiac output, which gives them the capacity to increase blood flow to the exercising muscles and to the skin, enabling sweating. Experientially, riders and endurance veterinarians acknowledge the value of this conditioning and adaptation in endurance horses, which accounts at least in part for requirements for qualification rides in the more challenging rides like the Tevis.

Conclusions

Our study provides evidence that the 20 horses with the fastest speeds throughout the 2019 Tevis competition had less dehydration than the other horses in the competition. We provide evidence that those horses that were pulled from the competition had greater levels of dehydration than those horses that continued in the ride.

While we feel our evidence is strong and is supported by other studies,[2,9,10] we acknowledge these findings should be substantiated by additional studies.

In his excellent review of dehydration, electrolyte balance and performance in endurance horses, Schott encouraged more use of body weight measurements at endurance rides to assess the hydration status of competing horses[2]. In addition, experienced trainers have devised "ideal competition weights" for horses using regular body weight measurements. Our studies support these conclusions.

Our study provides some foundation for discussion of variables that are important in their effects upon performance of endurance horses. While there is no direct evidence, numerous observations of endurance rides suggest very important factors in high performing endurance horses:

Superior athletic genetic makeup (all those inherent structural and biochemical traits that favor athletic performance specific to a sport)

Ability to take up large volumes of oxygen (oxygen uptake/minute) and convert the energy produced from the oxygen into efficient forward motion of their bodies

Strong aptitude and positive attitude toward the sport; i.e., how motivated is the horse to perform the specific athletic event (will-

ingness to compete), including tolerating training, conditioning and their rider(s)

High levels of adaption to all aspects of the sport

Capacity for high level of training and conditioning.

I think the substantially higher rates of speed, sustained high speeds over sections of difficult trail conditions, lower pull percentage and lower dehydration support the assertion that these horse-related variables are very important, if not the most important, to a horse's performance in challenging endurance rides.

A measure of an athlete's performance capacity is their ability to take up oxygen (volume of oxygen uptake/minute). Superior athletes are able to take up greater amounts of oxygen than others, and they are able to metabolically and mechanically convert the higher levels of energy into effective athletic performance, e.g., moving faster than others down the endurance trails.[2]

One could also make the case that the capability and capacity of the rider (and his/her crew) contribute substantially to the horse being able to realize its potential as a high-performing athlete. However, in a highly challenging endurance ride, such as the Tevis, it seems unlikely a less capable horse could achieve the speeds necessary to be in the top 20 even with a superior rider and crew members.

The rider or owner of a top performing horse has the capacity (good fortune) to choose a horse with superior genetic makeup for the sport. While much has been written about the characteristics of superior horses, there remains much to be learned about how these superior attributes are identified in a young horse. Some of the desirable horse-attributes will only be seen when the horse begins training, conditioning and competing.

An additional area that we will explore in a later article is the "art and science of electrolyte supplementation," which is given high priority by many accomplished endurance riders.

Finally, one could imagine that there are several goals and challenges encountered by the riders whose horses traveled at a slower speed throughout the Tevis competition. At some point in the ride, their predominant goal was likely to finish within the 24-hour time limit. The average speed of this group throughout the competition was close to the minimum speed required to finish within the allotted time. Hence, the rider's (and his/her horse's) challenge was to sustain a speed to meet the ride's time limit.

Finishing in these circumstances requires extraordinary effort on the part of the rider and horse. These horses have athletic talent (inherent genetic makeup), but on this day, it was not as great as the top 20 horses, and only additional training, conditioning and competitions may enable them to improve (prove) their athletic performance in endurance.

References

1. Schott, HC, et al. Am J. vet. Res.58:303-309, 1997
2. Schott, HC, Kentucky Equine Research, 94-111, 2010
3. Kingston, JK, et al. J. Appl. Physiol. 83(4): 1133-1143, 1997
4. Hyyppa, S, et al. Equine Vet J. Suppl. Jul (22):108-112, 1996
5. Meyer, H, et al. Adv. Anim Physiol Anim Nutri. 21, 21-34, 1990
6. Foss, MA. And Lindner, A. Pferdeheikunde. 1996; 12:435-437
7. Coenen, M. Livestock Production Science 92:131-145, 2005
8. Sawaka, MN, et al. Physiological Response to Exercise – Nutri-tional Needs in Hot Environments. National Academies Press, 1993
9. Larsson, J., et al. ISRN Veterinary Science, 2013: Article ID 684353, 2013
10. Hodgson, DR, et al. Brit. Vet. J. 150(3):S219-S235, 1994

Research volunteers, 2019 Tevis Study

Hiroko Bena-vivi	Martha Gillespie	May Tanaka
Bob Cronin	Cheryl Langbein	Niyoka Tanaka
Jessica Cronin	Tom Langbein	Forrest Tancer
Sheri Cronin	Lari Shea	Tally Wren
Jerry Gillespie	Aki Tanaka	Anne York

Acknowledgements The successful outcome of this study was dependent upon: 1) the willingness of the Tevis riders to participate in the study, 2) the dedicated and skilled work of the volunteers, 3) cooperation of the leadership of the Tevis organization, and 4) importantly the partial funding of the project by the Tevis Foundation and the American Endurance Ride Conference Research Fund.