INVESTIGATION OF TIME OF HAY FEEDING ON PLASMA VOLUME AND EXERCISE RESPONSE IN THOROUGHBRED HORSES

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Introduction

A common question asked regarding feeding the performance horse is when should the horse be fed hay relative to grain and exercise. Should the horse receive hay before, with or after a grain meal. Research in our laboratory (Pagan et al, 1997) with resting horses showed that time of hay feeding affected glycemic response to a grain meal and total plasma protein (TPP) concentration. Increases in TPP presumably reflect changes in plasma volume. The purpose of this experiment was to investigate whether time of hay feeding actually affects plasma volume and whether these changes affect metabolic response during an extended exercise bout.

Materials and Methods

Four mature Thoroughbred horses (2 mares and 2 geldings) were used in a 4X4 Latin square design experiment to determine whether method of feeding prior to a standardized exercise test (SET) will affect plasma volume and metabolic response to exercise. The SET used in this study was designed to mimic the exercise intensity and duration of the endurance day of a 3 day event. It was modeled after a similar SET designed by The Animal Health Trust.

The four dietary treatments included:

1. *(FAST)* 12 h fast prior to SET
2. *(AD LIB HAY +GRAIN)* Ad lib hay from 6 pm the night before and up to SET and 2.27 kg of a sweet feed mix 2 h prior to exercise,
3. *(HAY + GRAIN)* 2.27 kg of hay fed 3 h prior to SET and 2.27 kg of grain fed 2 h prior to exercise.
4. *(GRAIN)* 2.27 kg of hay fed at 10 pm the night prior to SET and 2.27 kg of grain fed 2 h prior to exercise on the morning of SET.

The grain was a mixture of 47% whole oats, 42% cracked corn, and 10% molasses. The grain contained 8.6% protein, 4.2% fat and 15.3 % neutral detergent fiber on an as fed basis. The hay was a mixed orchardgrass/alfalfa hay containing 20.4% protein, 1.9% fat and 36.9% neutral detergent fiber on an as fed basis.

The SETs were conducted weekly and the horses were trotted on an inclined treadmill for 20-30 min/day between tests. The SET was performed on an inclined treadmill (3^0) and consisted of a 10 min *walk*, 10 min *trot* (3.7 m/s), 2 min *gallop* (10.7 m/s), 20 min *trot* (3.7 m/s), 10 min *walk* and 8 min *canter* (9m/s). Heart rate was monitored throughout exercise. Three

hours before the SET, the horses were fitted with an indwelling catheter in the jugular vein. Blood samples were taken hourly before exercise (-3, -2, -1) and plasma volume was determined immediately before (pre) the SET using an indocyanine green clearance method (Parry et al, 1989) . During the exercise test, blood samples were taken during the last 30 seconds of each step of the exercise test, and 15, 30, 60, 120, 180 minutes after exercise.

Results and Discussion

The AD LIB HAY + GRAIN horses were significantly heavier at the beginning of the SET after having ad libitum access to hay during the 12 hour period before the SET (table 1). During this time, they consumed an average of 10.5 kg of hay.

Table 1. Body weight and plasma volume immediately before SET

	fast		grain		hay/grain		ad lib hay/grain	
horse #	BW (kg)	pv ml/kg	BW (kg)	pv ml/kg	BW (kg)	pv ml/kg	BW (kg)	pv ml/kg
1	555.5	45.66	547.3	46.07	538.0	49.72	557.3	44.0
2	485.3	49.68	507.3	48.26	492.7	45.33	510.9	46.27
3	490.0	49.89	485.5	51.77	493.5	53.37	494.4	49.79
4	537.3	50.21	538.0	50.18	549.0	51.74	561.5	40.97
AVE	517.0	48.86	519.5	49.07	518.3	50.04	531.0	45.26

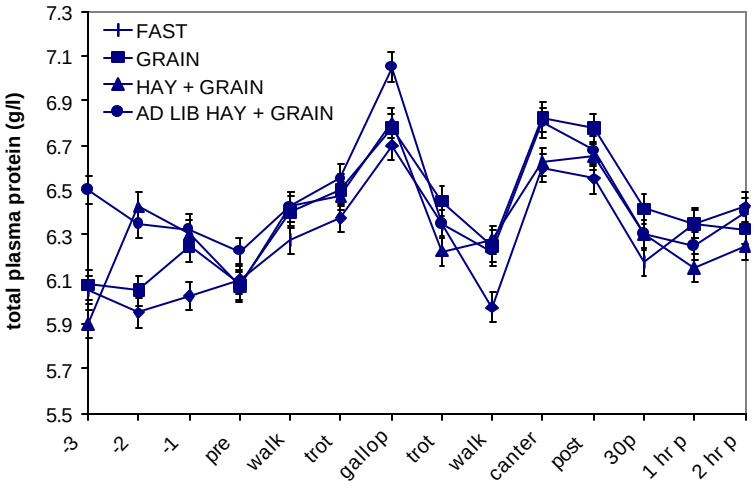

Figure 1. Total plasma protein (g/l) (mean ± SE)

AD LIB HAY + GRAIN plasma volumes immediately before the SET were also about 9% smaller (45.25 ml/kg BW vs 49.32 ml/kg BW) compared to the other three treatments. This was reflected in a higher total plasma protein (TPP) (6.23 vs. 6.08) compared to the other three treatments. TPP was elevated in HAY + GRAIN horses 1 hr after eating hay, but had returned to a fasting level when plasma volume was measured (figure 1). It appears that TPP does reflect changes in plasma volume, but unfortunately the time when plasma volume was measured in this experiment coincided with very small differences in TPP.

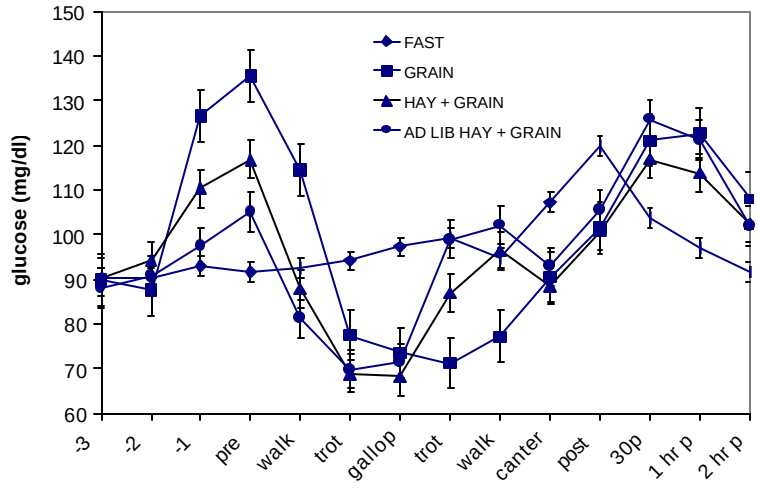

Figure 2. Plasma glucose (mg/dl) (mean ± SE)

At the end of the 2 min gallop, TPP was significantly higher in the AB LIB HAY + GRAIN group and TPP was significantly lower in the FAST treatment after the second 10 min walk.

Glycemic response to feeding was significantly affected by when and how much hay was fed (figure 2). When grain was fed alone (GRAIN), plasma glucose peaked 2 hours after feeding at 135 mg/dl. When hay was fed one hour before grain (HAY + GRAIN), glucose peaked at 117 mg/dl and when the horses had ad libitum access to hay for 12 hours before grain (AD LIB HAY + GRAIN), plasma glucose peaked at 105 mg/dl. These results are similar to an earlier experiment (Pagan et al, 1997) from our laboratory where feeding 2.27 kg of orchardgrass hay either with grain or 2 hours before grain caused a reduction in glycemic response. Meyer et al (1993) showed that substituting grass hay for ground alfalfa meal resulted in a decrease in the prececal starch digestibility of ground corn from 45% to 16%. They attributed this drop to changes in rate of passage and dilution of substrates and enzymes in the chyme due to increased secretion of digestive juices.

Following the 10 min walk and 10 min trot, plasma glucose in the grain fed horses dropped to levels around 70 mg/dl while the fasted horse's plasma glucose did not change significantly from pre-exercise levels. Following the 20 min trot, HAY + GRAIN and AD LIB HAY + GRAIN plasma glucose returned to near resting levels while GRAIN glucose remained near 70 mg/dl. GRAIN glucose probably remained low because of elevated plasma insulin which resulted in increased uptake by the working muscle (Pagan et al, 1996).

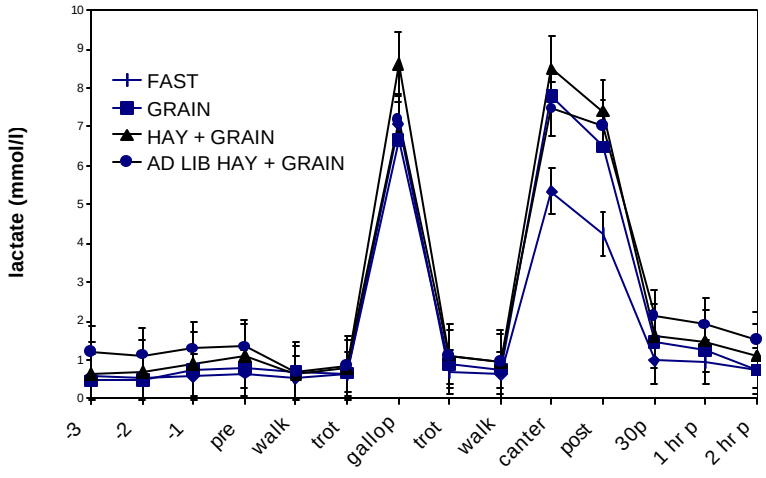

Figure 3. Plasma lactate (mmol/l) (mean ± SE)

Fasted horses had lower blood lactate after the 8 minute canter (5.34 mmol/l) compared to the other three treatments (7.92 mmol/l). It is not clear whether this difference was due to reduced lactate production by the muscle or a dilution of the lactate in a higher plasma

volume. Heart rate (HR) was significantly different between treatments. During the 2 min. gallop (10.7 m/s), FAST HR averaged 191 while AD LIB HAY + GRAIN equaled 206. During the 8 min canter (9 m/s), FAST HR averaged 176 while the HR for the AD LIB HAY + GRAIN equaled 191. HR for GRAIN and HAY + GRAIN were intermediate, averaging 183 and 189, respectively.

Conclusions

The results of this experiment suggest that an overnight fast before an extended bout of exercise may be beneficial. Fasted horses maintained resting levels of plasma glucose throughout exercise and had significantly lower levels of plasma lactate after the 8 min canter, a step of the SET that would be equivalent to the cross country portion of a 3 day event.

Allowing free choice access to hay the night before the SET resulted in an increase in body weight and a reduction of plasma volume. Heart rate was also elevated throughout exercise in these horses. In should be emphasized, however, that the horses had been limit fed hay up until the night before the AB LIB HAY, so they were unaccustomed to getting free choice hay. As a result, they gorged themselves on hay, eating a much higher level (10.5 kg) than would be expected from a horse that always received free choice hay. Also, the hay used in this experiment was high in protein and low in fiber which may have contributed to the high rates of intake. Certainly, if the horses were accustomed to free choice hay and if the hay were higher in cell wall content, then hay intake would have been lower and the reduction in plasma volume would be less dramatic.

It remained to be determined how feeding just hay before an extended bout of exercise would affect performance.

References

Meyer, H., S. Radicke, E. Kiengle, S. Wilke, and D. Kleffken (1993) Investigations of Preileal digestion of oats, corn and barley starch in relation to grain processing. In: Proceedings of the 13th ENPS, Gainesville, FL, pp. 92-97.

Pagan, J.D. (1997). Carbohydrates in equine nutrition. In: Proceedings of KER Equine Nutrition Conference, Lexington, KY.

Pagan, J.D., I. Burger and S.G. Jackson (1996). The influence of time of feeding on exercise response in thoroughbreds fed a fat supplemented or hihg carbohydrate diet. World Equine Vet. Review, 1:2, 43-44.

Parry, B.W., W.M. Bayly and B. Tarr (1989) Indocyanine green clearance and estimation of plasma volume in the normal horse. Equine Vet. J, 21:2, 142-144.