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# TIME OF FEEDING CRITICAL FOR PERFORMANCE

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## Introduction

One of the most frequently asked questions regarding feeding the performance horse is when to feed before a competition. Several studies have evaluated how feeding grain before exercise affects plasma concentrations of nutrients and hormones and substrate utilization during exercise (Rodiek et al., 1991; Zimmerman et al., 1992; Lawrence et al., 1993; Lawrence et al., 1995; Stull and Rodiek, 1995; Duren et al., 1998). In each of these studies, a pre-exercise concentrate meal suppressed free fatty acid (FFA) availability and enhanced glucose uptake by muscle during exercise. Forage was not fed with the concentrate in any of these studies. Thus, it is not known whether feeding hay along with grain will alter substrate availability during exercise. Therefore, a series of experiments was conducted to first evaluate how feeding forage along with grain influences plasma variables and water intake and then to determine whether these changes affect exercise performance. Additionally, a study was conducted to determine how forage alone affects exercise response. Since time of feeding is particularly important for three-day event horses, the exercise test used was a competition exercise test (CET) performed on a high speed treadmill and designed to simulate the physiological and metabolic stresses of the speed and endurance test of a three-day event (Marlin et al., 1995).

## Timing of Hay Relative to Grain Feeding

Surprisingly, the type of forage and time that it is fed relative to grain can have a large effect on fluid balance and prececal starch digestibility. 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%. He attributed this drop to changes in rate of passage and dilution of substrates and enzymes in the chyme by increased secretion of digestive juices.

KER has conducted research to determine how the timing of hay feeding relative to a grain meal affects plasma variables and water intake in Thoroughbreds. In this study, six Thoroughbred horses received 2.27 kg of orchardgrass hay at three different times relative to a 2.27 kg grain meal. Treatment 1 (hay/+4h) received hay 4 h after grain. Treatment 2 (hay/-2h) received hay 2 h before grain and Treatment 3 (hay/0h) received hay and grain together. Blood samples were taken immediately before and for 8 h post grain feeding. Insulin, glucose, lactate, total plasma protein and hematocrit were measured in each sample. Water intake was measured hourly throughout the test.

Feeding hay either before or with grain significantly reduced the glycemic response of the grain meal. Insulin production post feeding was also reduced. In addition, when hay was fed, total plasma protein (TP) became elevated in the next hour's blood sample. Interestingly, feeding only grain resulted in essentially no change in TP, even though the level of grain intake (2.27 kg) was the same that elicited a large change when hay alone was fed. Water intake was significantly influenced by time of hay feeding. Following hay feeding, water intake was greatly increased. The increase in water intake also corresponded to increased TP, suggesting that decreased plasma volume may have triggered a thirst response.

The large increase in TP seen with hay feeding probably resulted from a decrease in plasma volume due to greater saliva and digestive juice production. Plasma volume has been reported to drop by as much as 24% in response to a large meal, and this drop was accompanied by hyperproteinemia (Clarke et al., 1990). Kerr and Snow (1982) found that feeding hay, but not concentrates, caused elevations in hematocrit and TP. Meyer et al. (1985) measured the amount of saliva produced when horses ate either hay, pasture or a grain feed. When fed hay and fresh grass, the horses produced 400-480 g of saliva per 100 g of dry matter consumed. When a grain-based diet was offered, the horses produced only about half (206 g/100 g DM intake) as much saliva.

The decrease in glycemic response with hay feeding was probably a result of an increased rate of passage of the grain through the small intestine which resulted from greater volumes of fluid (saliva and drinking water) in the GI tract. Further evidence that hay feeding reduced grain digestibility in the small intestine is supplied from plasma lactate levels post-feeding. Plasma lactate increased 3 h after grain feeding when hay was fed either after or along with grain, suggesting the grain may have been fermented in the large intestine in these treatments. If feeding hay before or along with grain increases rate of passage to the point that prececal starch digestibility is compromised, then this should be discouraged since excessive starch fermentation in the hindgut can lead to a number of problems including colic and laminitis (Clarke et al., 1990).

When grain was fed alone, there was a dramatic drop in hematocrit in the 2 h post-feeding. It is not known why this occurred or if it is of physiological significance, but it certainly brings into question the relevance of resting hematocrit values when sampling times are not standardized. In fact, resting blood samples are probably of limited use anytime to assess red cell status. Persson (1979) examined resting hemoglobin values in Standardbred horses, with daily blood samples collected for 7 days. He reported up to a 30 percent variation in resting Hb values and warned that they provided no useful indication of total body Hb.

## **Feeding and Exercise**

The above study clearly demonstrated that feeding hay and grain markedly affects glycemic response and fluid balance in resting horses. Do these changes affect the horse during exercise? To answer this question, KER conducted a

second experiment in which four mature trained Thoroughbred horses were used in a 4 X 4 Latin square design to determine whether feeding grain with or without hay prior to a treadmill competition exercise test (CET) would affect substrate utilization and performance.

The four treatments tested were: (1) (FASTED) 2.27 kg of hay at 2200 h the day before but no grain or hay on the morning of CET; (2) (GRAIN only) 2.27 kg of hay at 2200 h the day before and 2.27 kg of grain 2 h before CET; (3) (GRAIN + AM HAY) 2.27 kg hay at 2200 h the day before and 2.27 kg hay 3 h before CET and 2.27 kg grain 2 h before CET; (4) (GRAIN + AD LIBITUM HAY) Ad libitum hay from 1800 h the day before and 2.27 kg grain 2 h before the CET.

The exercise test used was a competition exercise test (CET) carried out on a high speed treadmill which was designed to simulate the physiological and metabolic stresses of the speed and endurance test of a three-day event (Marlin et al., 1995). The CET was performed on an inclined treadmill (3°) and consisted of a 10 min walk (*Phase A*) (1.4 m/s), 10 min trot (*Phase A*) (3.7 m/s), 2 min gallop (*Phase B*) (10.7 m/s), 20 min trot (*Phase C*) (3.7 m/s), 10 min walk (*Phase C*) (1.4 m/s) and 8 min canter (*Phase D*) (9.0 m/s). Following exercise, the horses were hand walked for an additional 30 min.

Blood samples were taken hourly before exercise, during the last 30 s of each speed, and 30, 60, and 120 min after treadmill exercise. Insulin, cortisol, glucose, lactate, total plasma protein and hematocrit were measured. Body weight and plasma volume were measured immediately before exercise. Heart rate was recorded during the final 30 s at each speed throughout the CET.

A third experiment was conducted where four mature trained Thoroughbred horses (2 mares and 2 geldings) were used in a 4 X 4 Latin square design experiment to determine whether feeding forage but no grain prior to a treadmill competition exercise test would affect substrate utilization and performance.

The treatments tested were: (1) (FASTED) 2.27 kg grass hay fed at 2200 h the day before CET and no hay or grain the morning of the CET; (2) (AM HAY) 2.27 kg grass hay fed at 2200 h the day before and 2.27 kg of hay 3 h before the CET; (3) (AD LIBITUM HAY) For 7 d before the CET, horses were offered 5-6 kg of grass hay at 2200 h, 1.13 kg hay at 1200 h and 2.27 kg at 1600 h. If all of the hay was consumed during the night before the CET, the horses were offered an additional 2 kg of hay at 0600 h on the morning of the CET; (4) (GRAZING) For 7 nights before the CET, horses were housed in small grass paddocks from 1600 h to 0700 h and then they were placed in stalls and offered 2-2.5 kg grass hay. On the morning of the CET, the horses were removed from the grass paddocks at 0600 h, and they were offered no hay for 3 h before the CET. During these 7 d, the horses received no grain. The tests were conducted in late fall when the amount of forage available in these paddocks was sparse, but of high quality. The horses underwent the same CET as in Experiment 2 at 2 wk intervals. Blood sampling and analysis were also the same as in Experiment 2.

Data from Experiments 2 and 3 are combined in Figures 1a-1f. Fasted values represent four observations from Experiment 2 and four from Experiment 3 (n=8). Grain values represent all 3 grain treatments from Experiment 2 (n=12)

and forage values represent all three forage treatments from Experiment 3 combined ( $n=12$ ). From these figures, it is obvious that feeding grain before exercise has a large effect on glucose (Figure 1a) and insulin (Figure 1b) with a large drop in glucose occurring early in exercise, while feeding forage produced little effect on either parameter. Free fatty acids (Figure 1c) were also depressed in the grain fed horses preexercise and continued to be lower than either the fasted or forage fed horses throughout exercise. Plasma lactate (Figure 1d) appeared to be uninfluenced by diet as has been shown in other studies of feeding and exercise (Duren et al., 1998; Lawrence et al., 1995). Cortisol (Figure 1e) increased in all of the treatments throughout exercise, but appeared higher in the grain fed horses. Finally, TP was elevated both before and during exercise in the forage fed horses when compared to either the fasted or grain fed treatments (Figure 1f).

As in several other studies (Rodiek et al., 1991; Zimmerman et al., 1992, Lawrence et al., 1993; Lawrence et al., 1995; Stull and Rodiek, 1995; Duren et al., 1998), feeding grain before exercise with or without hay reduced FFA availability and increased glucose uptake into the working muscle. This would not be beneficial for horses competing in the speed and endurance phase of a three day event.

Feeding hay, either with grain or ad libitum the night before exercise, resulted in higher lactate production, heart rates, TP and hematocrit during exercise. Additionally, GRAIN + AD LIBITUM horses had elevated body weights and reduced plasma volume before exercise. Therefore, feeding hay along with grain before competition would appear to have no benefit as compared to feeding grain alone.

Feeding only forage before exercise had a much smaller effect on glycemic and insulin response to exercise than a grain meal. Additionally, feeding forage did not affect FFA availability. In the AM HAY fed horses, TP was elevated before and during exercise, and heart rate was elevated during the gallop in the AD LIBITUM HAY horses. Both of these responses in the hay fed horses were probably due to increased gut fill and a movement of water from the plasma into the gut. Even though the GRAZING horses tended to be heavier, they did not suffer from reduced plasma volume or elevated heart rates during exercise. This is probably because water was able to equilibrate between the plasma volume and gut so there was no reduction in plasma volume before exercise.

The results of these experiments indicate that feeding hay along with grain will result in a decrease of plasma volume and increase in body weight which may be detrimental to performance. Feeding grain either with or without hay 2 h before exercise will reduce FFA availability and increase glucose uptake by the working muscle. This is probably not desirable during prolonged exercise. Feeding only forage before competition does not appear to interfere with FFA availability and has no adverse effects other than possibly reducing plasma volume and increasing body weight. If forage is fed in small amounts or if time in a grass paddock is limited, then these effects will probably be minimal. Since completely withholding forage may lead to stomach ulcers (Pagan, 1997), the slight risk of reduced plasma volume and increased gut fill is more than outweighed by the potential benefit to the horse's long term health and well-being.

Figure 1a.

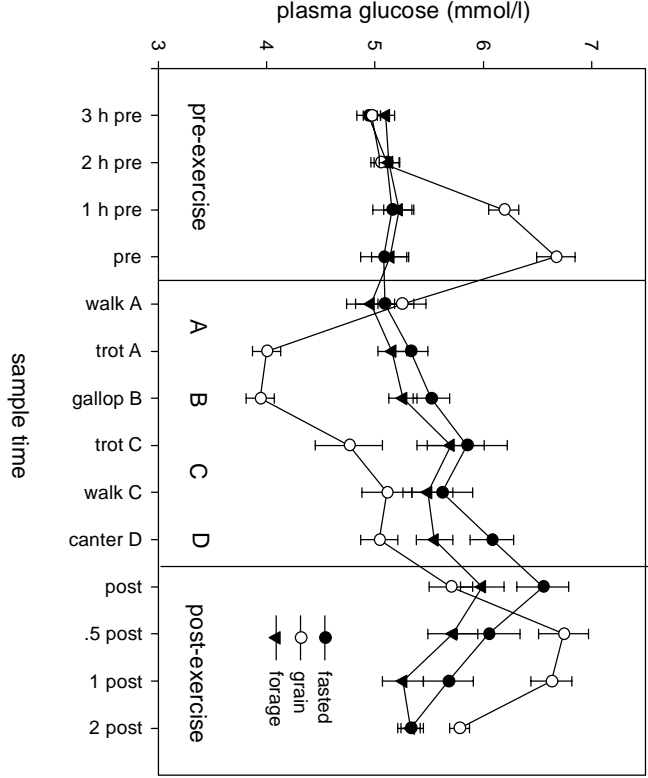
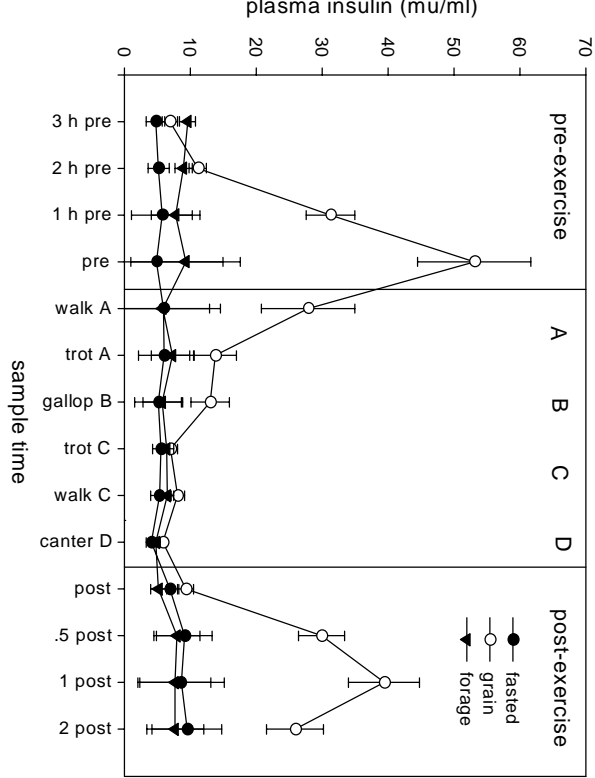
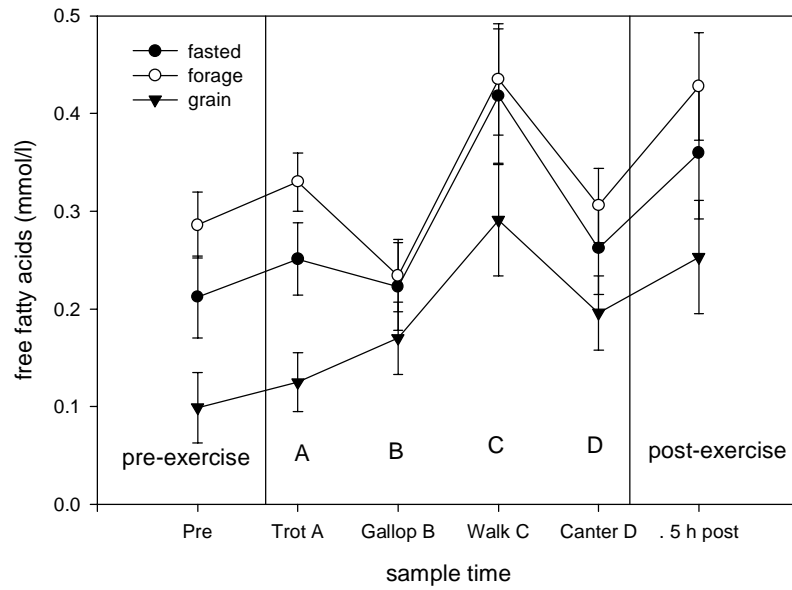


Figure 1b.



**Figure 1c.**



**Figure 1d.**

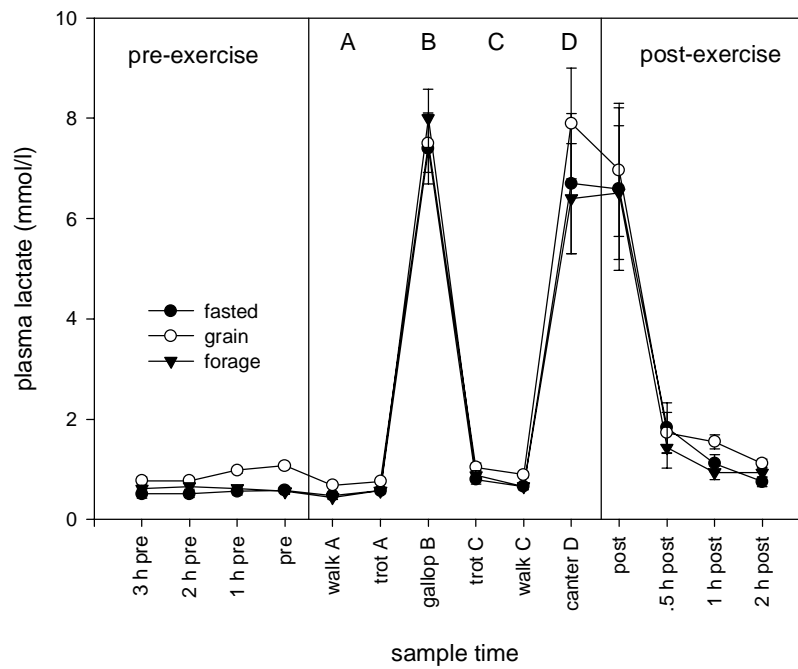


Figure 1e.

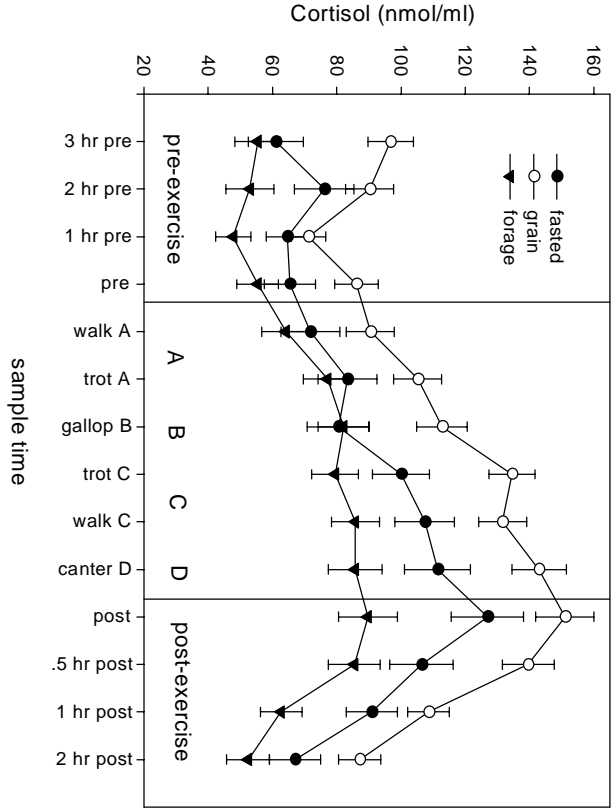
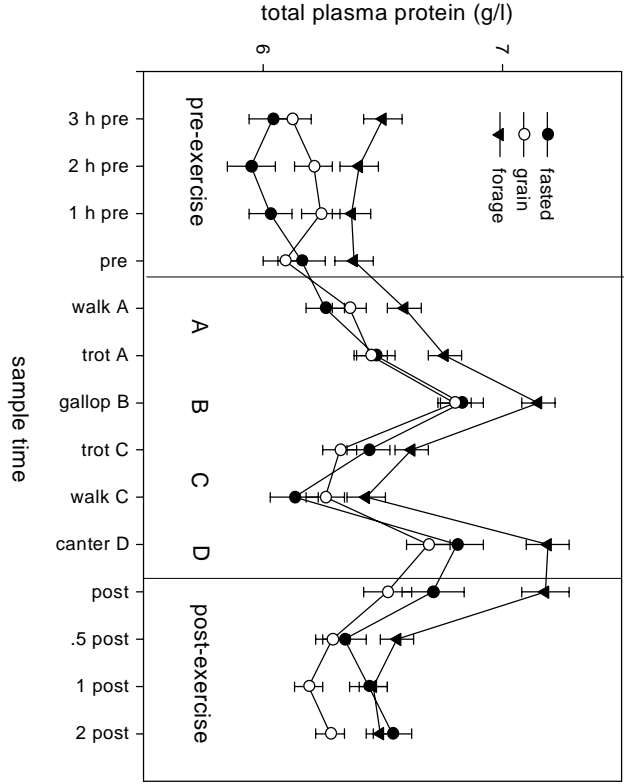


Figure 1f.





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