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A survey on the feeding of eventing horses during competition

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Summary

This study aims at the comparison of the actual feeding of horses with the recommendations from the literature, and it studies the effects of feeding and exercise on several blood metabolic parameters before and after exercise. Blood samples were collected from 25 horses during one-star eventing competitions and evaluated for blood glucose, insulin, lactate, free fatty acids and triglyceride levels. Questionnaires on the feeding practices of the horses were evaluated. The questionnaires revealed that during training, and on tournament days, horses received on average 4.3 kg of concentrate per day (min. 1.54 kg, max. 8 kg). The statistical analysis showed no significant effect of the amount of concentrate fed before exercise on the measured blood values. Oil was supplied as a supplementary energy source to 30% of the horses, but most of them only received very small quantities (0.02–0.4 l/day). Five horses (20%) had no access to salt supplements at all, and eleven horses (45%) had no access to salt on tournament days. Fifteen horses (60%) were supplied with mineral feed. Twenty-one horses (84%) had daily access to pasture during the training period. During competition, 55% of the horses received roughage *ad libitum*, compared with 37% during training. The majority of the horses received less roughage on days before the cross-country competition. It could not be ascertained whether feeding a large amounts of roughage had a beneficial effect on performance, because only a few horses in this study were fed with very restrictive roughage. Feeding of most of the horses was in agreement with the recommendations from the literature, except the need for sodium and chloride. The sodium and chloride need for sport horses may be overestimated in literature and needs to be re-evaluated.

Introduction

The feeding regime has a significant influence on energy supply and the performance of equine athletes. In the literature, it is generally assumed that short, intensive work is better supported by a starch- or glucose-rich diet, whereas a high-fibre and high-fat diet is more beneficial for long, persistent work at a medium intensity (Ellis and Hill, 2005). During 3-day eventing competitions, a horse is exposed to different types of exercise. According to the National Research Council's Nutrient Requirement of Horses, the energy and protein requirement of horses participating in high-level 3-day eventing competitions is 1.5–2.0 times that of a horse at maintenance (NRC, 2007).

Free fatty acids are used as a major energy source during endurance exercise (Harris and Harris, 2005). Thus, it is advisable that horses participating at 3-day eventing competitions should be offered roughage *ad libitum* until the beginning of exercise. Additionally, roughage is good for the water and electrolyte storage capacity. Hay should also be offered *ad libitum* after exercise [equivalent to 2–4%

of body weight (BW)]. Furthermore, a starch-rich meal of <0.3% of BW may be offered 2–4 h later (Vervuert et al., 2008). Horses that received a roughage-rich diet showed a greater capacity for gluconeogenesis compared with horses fed a starch-rich diet, and normal blood glucose levels can be maintained for a longer period (Frape, 1998). This is because up to 60% of equine blood sugar is produced in the liver via gluconeogenesis from propionate (Simmons and Ford, 1991). However, some authors recommend restrictive roughage feeding starting 3 days before intense exercise of short duration, because it causes less water uptake and storage in the intestine, reduces the body weight and reduces energy expenditure during running (Rice et al., 2001). The objective of this field study was to compare the practical feeding of eventing horses with recommendations in the literature and to study the influence of feeding time and volume on blood metabolic parameters to provide new insights into the feeding of eventing horses.

Material and methods

Riders of 25 different horses with 25 accounted tournament starts filled out a questionnaire on the feeding of their horses during training and on tournament days. The questions asked included: concentrate and roughage quantity and type as well as feeding time, in relation to exercise; feeding sequence and frequency per day; intensity and duration of training; adaptation of feeding to exercise levels; feeding of oil, salt and electrolytes; grazing time and duration; duration of transport to the tournament; the weight of the horse; and a detailed listing of the exact diet fed per meal and feeding times over the 3 days of the competition. The feeding regime was chosen from the riders or trainer and was not influenced by the study design. For this reason, the ranges of the time of feeding as well as the feed types and quantities are listed in the results section. The selection of horses evaluated consists of 11 thoroughbred/warm-blood cross-mares and 14 thoroughbred/warm-blood cross-geldings. The horses came from Switzerland (60%), Germany (38%) and England (2%) having an average age of 11 years (min. 6, max. 18 years). Blood samples were collected in the field from the horses during one-star 3-day eventing competitions. One competition was held in Switzerland, while the second occurred in Germany close to the Swiss border. Different disciplines were performed over 3 days in the following order: dressage, cross-country and show-jumping. Blood samples were taken 20–120 min before exercise, that is, after the last feeding but before the warm-up and within 10 min after the exercise. Blood samples were collected using EDTA Vacutainers© (BD Vacutainer, Allschwil, Switzerland). Blood glucose (Bayer, Zurich, Switzerland) and blood lactate (Arkray, Tokyo, Japan) were measured immediately after drawing the samples using a rapid test kit. Plasma was frozen and stored at −80 °C until analysis was performed. Insulin (Mercodia Equine Insulin ELISA; Mercodia AB, Uppsala, Sweden), triglycerides and free fatty acids were measured using an auto analyzer (COBAS MIRA Chemistry Analyzer; Roche, Basel, Switzerland) with commercially available tests (enzymatic colorimetric test, DIA 00660; Diatools, Roche, Basel, Switzerland). Body condition was estimated (scored 1–9) by the authors on tournament days, using the chart described in Schramme (2003).

Classification into groups for comparison of parameters

To determine the influence of the amount of concentrate fed before exercise on blood parameters, the horses were divided into three groups as follows. Group < 1 kg = horses fed <1 kg, group 1–2 kg = horses fed 1–2 kg, while group > 2 kg = horses were fed more than 2 kg concentrate at the last meal before exercise (independent from the feeding time point). To determine the effect on blood parameters of the time since feeding before exercise, the horses were divided into three groups as follows. Group < 2 = horses fed <2 h before, group 2–6 = horses fed 2–6 h before, while group > 6 = horses fed more than 6 h before exercise. To evaluate the effect on blood parameters of the amount of roughage fed before exercise, the horses were divided into three groups as follows. Group 0 kg = no roughage, group 1–3 kg = horses that received 1–3 kg roughage, while group > 3 kg = horses that received over 3 kg roughage prior to exercise.

Statistical analyses

Parameters were checked before and after exercise in the three different disciplines. Multivariate analysis of variance for repeated measures (MANOVA) was performed with the group as a cofactor included in the model to test differences of the time-dependent patterns between groups. The factor of sports discipline (exercise type) was included in the model. The test within subjects indicated whether significant changes occurred during the whole period for all animals. The factor sports discipline tested whether the changes differed between the different exercise types within the groups. The trend analysis was a breakdown of the tests within subjects, which gave an indication of the form of the changes over time. To avoid false conclusions because of a violation of the assumption of compound symmetry, a Huynh–Feldt correction was performed. Furthermore, the difference between groups at specific times was tested with the Mann–Whitney *U*-test (nonparametric) to limit the influence of extreme values. The level of significance was set at $p \leq 0.05$ for all tests. All statistical analyses were performed by using SYSTAT version 11.0 (SPSS, Chicago, IL, USA). If several tests were performed for one parameter, a Bonferroni adjustment of the significance level (p divided by the number of tests) was performed. All data were described in the text as median with maximum and minimum values.

Results

84.6% of the horses arrived at the show ground the day before the event, 10.3% arrived on the first competition day (four horses with a 20–60-min drive), while 5.1% returned home after each discipline (two horses: one with a 20-min drive and one with a 30-min drive). The feeding regime from the 25 horses is listed in Table 1. Nineteen horses of 25 had access to a salt lick during the training period (76%). Five horses (20%) had no access to salt at all during the training period. On the tournament days, seven horses (28%) had access to a salt lick. Seven horses received salt mixed with concentrate (5–35 g/day). Eleven horses (45%) had no access to salt on tournament days. Eight horses of 25 were supplemented with electrolytes (32%). Five of these received electrolytes once a day during training and on tournament days. The remaining three horses received electrolytes only after the cross-country or after cross-country and show-jumping. Fifteen (60%) horses were supplied with mineral feed. Ten horses received daily carrots and/or apples (on average 1.0 kg/day, max. 2 kg/day). During the training period, 21 horses (84%) had daily access to pasture. The mean time these horses spent on pasture was 2.09 h/day. On tournament days, 17 (68%) horses were allowed to graze on day 1 and 16 on day 2 and 3 (64%). The mean grazing time was half an hour on day 1 (min. 0.15 h, max. 1.75 h), 0.69 h on day 2 (min. 0.15 h, max. 4.0 h) and 1.02 h on day 3 (min. 0.15 h, max. 4 h).

Table 1 Feeding regime of 25 horses during training as well as on tournament days, before exercise and during the whole day

		Concentrate [kg]			Roughage			Pasture access/grazing [hours]				Oil [litre]				Mineral Suppl. [No. of horses]	Salt [No. of horses]				Electrolytes [No. of horses]	Meals per day [No. of horses]		
Discipline	Feeding period	Median	Min.	Max.	*ad libitum* (No. of horses)	Median (restricted access, in kg)	Min. (kg)	No. of horses	Median	Min.	Max.	No. of horses	Median	Min.	Max.	Yes	SL	SL + Salt	Salt	Non	One per day	≤2 meals	3 meals	≥4 meals
Training	Whole day	4.32	1.74	8.0	10	8	4	21	2.09	0.15	10	8	0.12	0.02	0.40	15	17	2	1	5	5	7	17	1
Dressage	Pre exercise	1.43	0	3.0	14	2	1.75	9	0.33	0.15	0.75	3	0.10	0.02	0.2	5	7	0	7	11	5	7	16	2
	Whole day	4.26	1.74	8.0	15	8.5	5	17	0.59	0.15	1.75	5	0.14	0.02	0.40	15								
Cross	Pre exercise	1.25	0	4.0	11	2	0	5	0.41	0.15	1.00	2	0.15	0.1	0.2	5	7	0	7	11	8	8	15	2
	Whole day	4.28	1.5	9.5	17	9	3.5	16	0.69	0.25	4.00	4	0.17	0.1	0.4	15								
Show	Pre exercise	1.49	0	4.0	16	3	1	7	0.51	0.15	1.50	4	0.12	0.1	0.2	5	7	0	7	11	8	7	17	1
jumping	Whole day	4.40	1.5	10.0	17	9	5	16	1.02	0.10	4.00	4	0.17	0.1	0.4	15								

Salt: SL, Salt lick; Salt, additional salt to the concentrate.
Roughage: *ad libitum* (free access).

Horses body condition scores were mainly 4–5 of 9 (Schramme, 2003). Twenty-two horses were fed commercially available compound mixes based on grain. Six of these horses received additional grain (four oats, two corn, two linseed and one bran). The remaining three horses received only oats. Horses were fed 4.34 kg of concentrate during the training period and on tournament days (min. 1.5 kg, max. 8 kg), which was divided into one to five meals. The statistical analysis showed that there was no significant effect of the amount of concentrate fed before exercise on blood glucose, lactate, free fatty acids and triglyceride values. Horses received 0.2 kg less concentrate (1.25 kg, min. 0 kg, max. 4 kg) before cross-country compared with dressage and show-jumping (1.4 kg, min. 0 kg, max. 4 kg). The eventing horses were fed 50 min (min. 1.75 h, max. 16.5 h before the start) earlier before cross-country, than before dressage and 6 min earlier in relation to show-jumping. The blood glucose resting value before cross-country was significantly lower compared with dressage and show-jumping ($p < 0.05$; see Table 2).

Three of 25 horses received silage. The remaining 22 horses were fed hay. Most of the horses had free access to roughage during training as well as on tournament days. The quantities of roughage fed are listed in Table 1. More roughage was provided on tournament days than during the training period. The insulin and blood glucose levels in the 0 kg group (of roughage) tended to be lower (p = 0.053/ 0.058), and the resting free fatty acids values were higher (p = 0.050) than in the other two groups. The amount of roughage fed had no effect on lactate and triglyceride levels.

Table 2 shows blood values for glucose, insulin, lactate, triglyceride and free fatty acids before and after dressage (DRE), cross-country and show-jumping (SJ) for all 25 horses participating in this study. The median blood glucose concentration increased most during cross-country compared with the other two disciplines (DRE, p = 0.042; SJ p = 0.005). The anaerobic threshold of 1.3–4 mM (Sexton et al., 1987; Lindner, 2010) was only exceeded by a few horses during dressage, frequently during show-jumping, but by all horses during cross-country. The horses reached median lactate concentrations of 6.7 mM after cross-country (min. 2.4 mM, max. 14.9 mM). A decrease (p = 0.0001) in plasma insulin concentration was found in all disciplines, as was expected (Table 2). Horses exhibited increases (p = 0.0001) in their triglyceride values during cross-country and show-jumping. There was also an increase (p = 0.0001) in blood free fatty acids concentration with all three disciplines (Table 2).

The times of feeding were adapted by the riders to fit the competition schedule. Therefore, the horses were not fed at the same times of day as at home. The last meal before exercise was given 4:30 h (min. 1 h, max. 16 h) before dressage, 5:20 h (min. 1:45 h, max. 16:30 h) before cross-country and 5:14 h before show-jumping (min 1:30 h, max. 16:20 h). The influence from the last feeding time point before exercise on the blood values of insulin, glucose, lactate, triglyceride and free fatty acids could not been evaluated statistically because of the small number of horses in each group (two horses in the group < 2; seventeen horses in the group 2_ to _6; six horses in the group > 6).

Eight horses 25 (32%) were fed oil additionally. The average rate was 0.12 l/oil/day (min. 0.02 l/day, max. 0.4 l/day), and the oil was generally added to the last concentrate fed of the day. There was no effect of oil feeding on glucose, lactate, insulin, triglyceride or free fatty acids values.

Table 2 Median, minimum and maximum blood values for glucose, insulin, lactate, triglyceride and free fatty acids before and after dressage, cross-country and show-jumping for all 25 horses

Discipline	Pre/Post exercise	Glucose (mM)			Insulin (μg/l)			Lactate (mM)			Triglyceride (mM)			Free fatty acids (mM)		
		Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.
Dressage	Pre	4.8	4.2	5.6	0.12	0.06	0.39	0.6	0.6	0.9	0.26	0.02	0.39	0.148	0.017	0.478
	Post	5.2	2.9	13.8	0.04*	0.01	0.30	0.6*	0.6	1.9	0.26	0.04	0.47	0.441*	0.096	0.816
Cross	Pre	4.4†	3.8	5.9	0.14	0.04	0.48	0.6	0.6	0.9	0.27	0.16	0.40	0.035†	0.006	0.382
	Post	6.2*†	3.8	20.9	0.09*†	0.02	0.28	6.7*†	2.4	14.9	0.36*	0.23	0.58	0.226*†	0.068	0.601
Show	Pre	4.8§	3.7	6.0	0.10§	0.04	0.31	0.6§	0.6	1.2	0.29	0.14	0.43	0.107§	0.022	0.646
jumping	Post	4.5*§	2.9	8.0	0.05*§	0.02	0.12	1.4*§‡	0.6	4.6	0.31*†	0.19	0.49	0.328*	0.047	0.621

*p < 0.05, pre exercise value versus post exercise value.

†p < 0.05, dressage versus cross.

‡p < 0.05, dressage versus show jumping.

§p < 0.05, cross versus show jumping.

Discussion

In two previous CCI3*-eventing studies in the United States, it was found that 76% of the riders fed a commercial mixed feed as well as cereal grain, beet pulp, wheat or rice bran product to their horses at an average of 13.7 ± 0.9 kg/day (Burk and Williams, 2008; Leahy et al., 2010). In Australia, the Olympic eventing horses obtained concentrate in volumes between 1.48% and 2.45% of body weight (i.e. 10 kg concentrate per horse per day) (Owens, 2005). The eventing horses in the present study were fed clearly less concentrate (median 4.3 kg, min. 1.5 kg, max. 8 kg) than mentioned US and Australian eventing horses. This is maybe due to a higher competition level of the horses evaluated in the American and Australian study in relation to the eventing horses described here. 100% of horses in an US elite-level eventing study experienced at least one nutrition-associated problem (gastric ulcer, weight loss, exertional rhabdomyolysis and so on) (Leahy et al., 2010). Owens (2005) recommended a grain intake by horses fed two or three times daily limited to 0.5 kg of grain 100 per kg of body weight per meal, to prevent starch overload, that is, approximately 2.7 kg concentrate per meal horse. This value was not reached by most of the feeding regimes evaluated in the present study. Regarding the questionnaires, only one horse had exertional rhabdomyolysis, and none was treated with drugs against gastric ulcer nor were other nutrition-associated problems mentioned.

The amount of concentrate fed before exercise had no effect on blood glucose, lactate or free fatty acids levels. The lowering effect on free fatty acids blood values of a starch-rich diet (Zimmerman et al., 1991) was not observed in the current study. The amounts of concentrate fed may have been too low to greatly influence free fatty acids levels.

A glucose-sparing or lactate-lowering effect was not detected with oil feeding. It is possible that the amounts of oil administered were too low to provide the beneficial effects described in the literature (Greiwe et al., 1989; Frape, 1998; Dunnett et al., 2002; Mattos et al., 2006). Alternatively, it may be that the oil was fed at the wrong time in relation to the commencement of exercise, that is, the majority of the horses received oil in the evening.

The fact that five sport horses (20%) performing at this level of performance never had access to salt, and 13 horses (52%) had no access to salt during the three tournament days, seemed to be alarming if compared to actual recommendations (Frape, 1998; Harris and Harris, 2005; NRC, 2007). The small amount of salt found in commercial mixed feeds is far too low to meet the needs of sport horses, because it is only present at approximately 3 g/kg concentrate. A horse's standard requirement for sodium is 20 mg/kg BW/day (Harris and Harris, 2005), and even with moderate work, they can lose approximately 100 g of salt per day (Frape, 1998). It may take over 24 h to replace weight losses caused by the cross-country phase of a 3-day event (Andrews et al., 1995), and water as well as electrolytes replenishment is warranted for a successful show-jumping performance at day 3. Administration of an electrolyte or sodium chloride solution after exercise helps to overcome dehydration better than water alone (Hiney and Potter, 1996; Hyyppä et al., 1996). The fact that 20% of the horses in this study received consistently a sodium chloride quantity much lower than recommended, but still performed well during competition may indicate that the need of sodium and chloride for sport horses may be overestimated like it was suggested by Romanowski et al. (2011). In relation to US CCI3*-eventers evaluated in 2007, where 92% of horses were supplemented with electrolytes (Burk and Williams, 2008), only a few of the horses in this study received electrolytes (33.3%), and more than half of these horses received the same quantity of electrolytes every day without adapting the dose to their needs.

The differences in glucose, insulin and free fatty acids resting values before cross-country in relation to resting values before the other two disciplines can be explained by a different feeding regime on the day of the cross-country. The time of blood sampling before exercise also varied greatly, because of the tournament schedule. It was not always possible to take blood samples at the same point of time. Blood was taken after the last feed, but before the start of the warm-up. These temporal differences may have influenced the resting blood values.

Insulin concentrations generally decrease during stress, regardless of decreases in the glucose level (Church et al., 1987). This was confirmed in the present study. The horses exhibited increased triglyceride levels, indicating a mobilization from adipose tissue. A higher increase in triglyceride occurred during the cross-country compared with dressage ($p = 0.047$) and show-jumping ($p = 0.0001$) confirming a relationship between exercise intensity and the extent of triglyceride increase, as mentioned in the literature (Pösö et al., 1989).

Most of the US eventing horses evaluated in 2007 had feed withheld for approximately 2–4 h prior to the cross-country (Burk and Williams, 2008). The same feeding manner could be seen in this study.

The majority of horses arrived the day before the tournament started. Only a few horses with very short drives went back home after each discipline, so it was assumed that the effects of transportation had little influence on the blood values recorded in this study. The relatively restricted access to pasture reflects the current practice for (especially Swiss) sport horses. There is too little pasture land available, and there is a deep-set fear of tired horses with big, grass-filled bellies in the sport riders' population.

There is a discrepancy in the literature regarding the influence of the amount of roughage on lactate values during exercise. Rice et al. (2001) reported higher resting and post-exercise lactate levels in groups with free roughage access. However, the amount of roughage fed before exercise had no influence on lactate levels in the current study. There is a general consensus that water and electrolytes in the intestine can delay the onset of fatigue because of dehydration and electrolyte loss during long-lasting, stressful work (Zeyner, 2008). Further on a hay-based diet seems to buffer the postprandial acidifying effect of NaCl supplementation (Romanowski et al., 2011). It could not be ascertained whether a large amount of roughage had a beneficial effect on performance, because only a few horses in the present study were fed with very restrictive roughage. Most of the eventing horses were fed a diet rich in roughage, following published recommendations (Heppes, 2003).

Generally, feeding of most of the horses was in agreement with recommendations from literature, besides the need for sodium and chloride, and the remarkably small amount of concentrate fed in relation to other sport disciplines as well as in relation to US and Australian elite-level eventing horses. The need of sodium and chloride for sport horses may be overestimated in literature and needs to be re-evaluated.

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