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THE EFFECT OF CHROMIUM SUPPLEMENTATION ON METABOLIC RESPONSE TO EXERCISE IN THOROUGHBRED HORSES

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Introduction

Chromium has been recognized as an essential nutrient in humans for many years (Mertz, 1992). Though chromium may well be involved in other physiological processes, at present its only known role is as a component of glucose tolerance factor (GTF) which potentiates the action of insulin. Therefore, it is involved in carbohydrate metabolism and other insulin dependent processes such as protein and lipid metabolism. A number of recent experiments have evaluated the effect of supplemental chromium in a wide range of species including humans, cattle, pigs, and turkeys. In these studies, chromium supplementation has increased lean muscle deposition (humans and swine), improved immune response (cattle), and reduced cortisol production caused by heat and transport stress (cattle and swine). No research, however, has been conducted with chromium in horses. Therefore, the following study was conducted to determine the effect that chromium supplementation has on metabolic response to exercise in trained Thoroughbred horses.

Material and Methods

Six trained Thoroughbred horses (4 gelded males, 2 females) were used in this 2 period switch-back design experiment. The horses were divided into two groups which received identical diets with one group (CHROM) also receiving 5 mg of chromium from a chromium yeast product (Co-Factor III, Alltech, Inc.). The diet consisted of a textured grain mix, forage cubes and orchard grass hay. Amounts and compositions are listed in Tables 1 and 2. At the conclusion of the first period, the diets were switched and the horses repeated the same exercise and testing regime.

During each 14 day period, the horses were exercised on a high speed treadmill (Beltalong, Eurora, Australia) inclined to 3° according to the schedule outlined in table 3. Heart rate was monitored on a daily basis (Hippocard PEH 200). At the end of each period, the horses performed a standardized exercise test (SET) on the treadmill. On the test day, each horse received 1.36 Kg of hay cubes 5 hours before the SET

and 1.81 kg grain 3 hours before the test. Blood samples were collected from an indwelling jugular catheter after an 8 hour overnight fast, before grain was fed and hourly after feeding for 3 hours. The SET began at 3 hours post feeding and consisted of a 2 minute warm-up walk followed by an 800 m trot (~4 m/s), then 800 m gallops of 8 m/s, 9 m/s, 10 m/s and 11 m/s. These gallops were followed by an 800 m warm-down trot and 2 minute walk. During the SET, a blood sample was taken after the warm-up trot, during the last 15 seconds of each gallop and after the warm-down walk. Blood samples were also collected at 15 and 30 minutes post exercise. Heart rate was recorded at each speed.

Table 1. NUTRIENT CONCENTRATIONS OF EXPERIMENTAL FEEDS

<i>Nutrient</i>	<i>Sweet feed</i>	<i>Orchard grass hay</i>	<i>Forage cubes</i>	<i>Chromium yeast</i>
Dry matter (%)	85.5	91.0	91.6	92.3
Crude protein (%) ¹	14.2	15.8	16.7	48.6
Acid detergent fiber (%) ¹	9.8	34.9	37.3	3.7
Neutral detergent fiber (%) ¹	19.3	54.5	49.9	17.9
Lignin % ¹	2.4	5.9	8.0	-
Ether extract (%) ¹	4.7	3.2	2.2	0.9
Soluble CHO (%) ^{1,2}	55.85	17.08	21.47	26.33
Calcium (%) ¹	0.71	0.76	1.40	0.15
Phosphorus (%) ¹	0.62	0.40	0.27	1.22
Magnesium (%) ¹	0.22	0.16	0.24	0.21
Potassium (%) ¹	0.86	3.20	1.96	1.84
Sodium (%) ¹	0.241	0.012	0.03	0.084
Iron (ppm) ¹	363	135	460	157
Copper (ppm) ¹	30	7	7.9	51
Zinc (ppm) ¹	98	19	22	192
Chromium (ppm) ¹	2.6	0.30	0.74	1008

¹ dry matter basis

² soluble CHO = 100-CP-EE-NDF-Ash

Table 2. DAILY FEEDING SCHEDULE

	<i>Sweet feed</i>	<i>Orchard grass hay</i>	<i>Forage cubes¹</i>	<i>Chromium yeast</i>
07.00 am	1.81 kg		1.36 kg	
12.00 pm		1.13 kg		
17.00 pm	1.81 kg		1.36 kg	5 grams
22.00 pm		1.13 kg		

¹ AlfaOats, Canadian Agra Bio-cube, Kincardine, Ontario

Table 3. EXERCISE SCHEDULE

	<i>Period 1</i>	<i>Period 2</i>
3 times per week	1600 m @ 7 - 8 m/s	1600 m @ 8 - 9 m/s
4 days before SET	1600 m @ 10 m/s	1600 m @ 10 m/s
3 days before SET	no exercise	no exercise
2 days before SET	1600 m @ 8 m/s	1600 m @ 8 m/s
1 day before SET	no exercise	no exercise

Each blood sample was placed in a sterile tube containing EDTA and centrifuged immediately. The plasma was pipetted into glass tubes, measured for lactate and glucose and then frozen. Plasma glucose was measured using an automated glucose analyzer (YSI, 2300 STAT). Lactate levels were measured using an automated L-lactate analyzer (YSI, 1500 Sport). The following day, the frozen plasma was analyzed for triglycerides and cholesterol (Eppendorf 5060 Automated Analyzer, Gibbstown, New Jersey). At the conclusion of the study, all of the frozen plasma samples were analyzed for insulin and cortisol using commercially available radioimmunoassay (RIA) kits which had been validated for specificity and accuracy in equine plasma (BET Labs, Lexington, Kentucky). Variables were analyzed by analysis of variance using animal, period and treatment as main effects (NCSS, Kaysville, Utah).

Results

Plasma glucose (figure 1) in both groups peaked 1 hour after the grain meal the morning of the SET. Glucose tended to be higher in the control (CON) horses at this time (121.8 vs. 116.8 mg/dl, $p=0.18$). At the onset of exercise, glucose was still elevated above fasting levels in both groups. During exercise, glucose decreased with each step. Glucose was significantly lower than the CON ($p<0.05$) in the CHROM group after the 8 m/s and 9 m/s steps. During the warm-down phase of the SET, glucose rebounded to fasting levels in both groups and glucose was not different ($p>0.10$) 15 or 30 minutes post exercise.

Plasma insulin (figure 2) increased following feeding in both groups. Insulin peaked in the CON group 1 hour after grain, while the peak in the CHROM group didn't occur until 2 hours after grain was fed. Blood insulin was lower in the CHROM group than the CON (163 vs 129 uU/ml, $p<0.10$) 1 hr after grain feeding.

Plasma lactate (figure 3) increased in both groups throughout the SET, peaking in both groups following the final gallop step. Lactate was lower in the CHROM group (8.65 vs. 7.55 mmol/l, $p=0.08$) after the 11 m/s step.

Cortisol (figure 4) was significantly lower in the CHROM group 3 hours after feeding ($p<0.01$), after the warm-up trot ($p<0.05$) and after the 8 and 11 m/s steps ($p<0.10$).

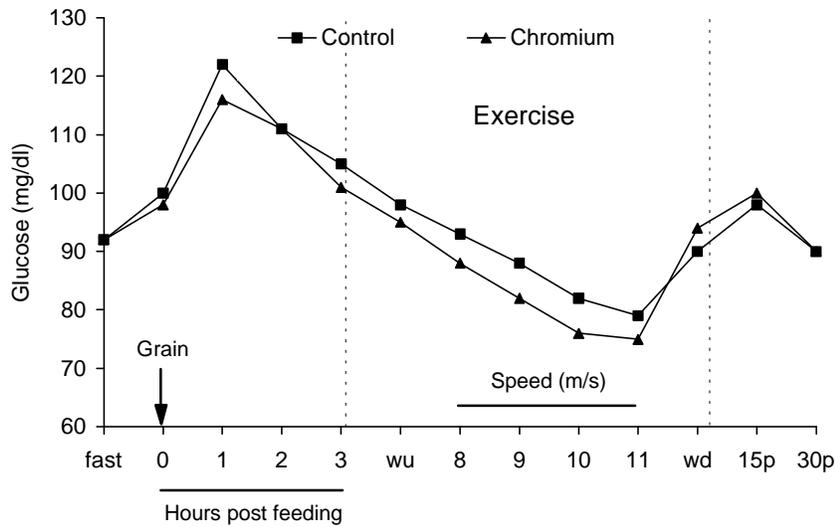


Figure 1 Plasma glucose (mg/dl)

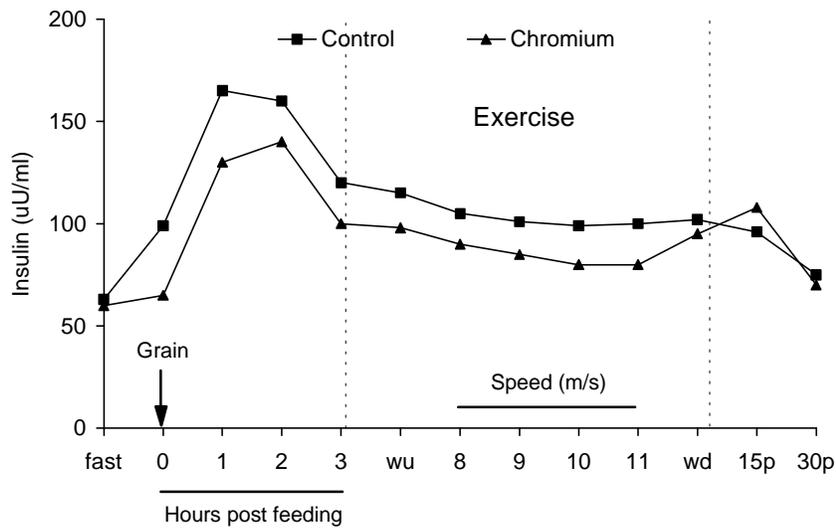


Figure 2 Plasma insulin (uU/ml)

Triglycerides (figure 5) tended to be higher in the CHROM group than the CON following the 10 and 11 m/s steps and were significantly higher in the CHROM group 15 and 30 minutes post exercise ($p < 0.05$). Heart rate (figure 6) and cholesterol were unaffected by diet.

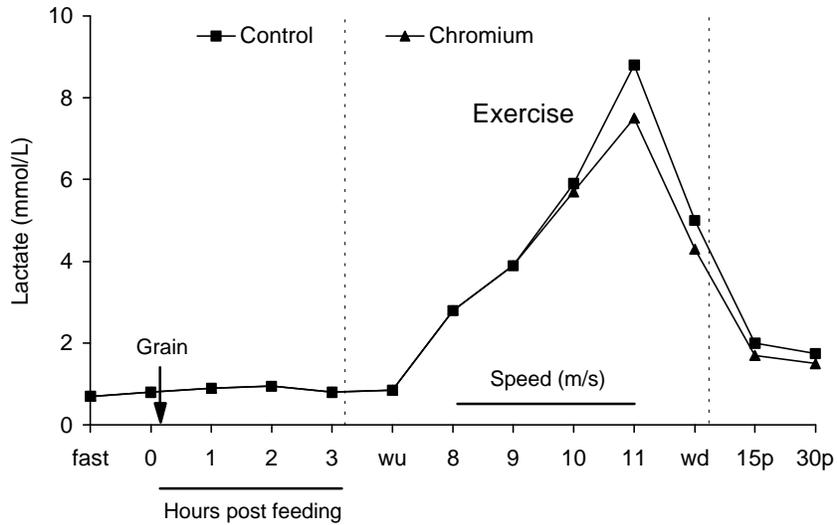


Figure 3 Plasma lactate (mmol/l)

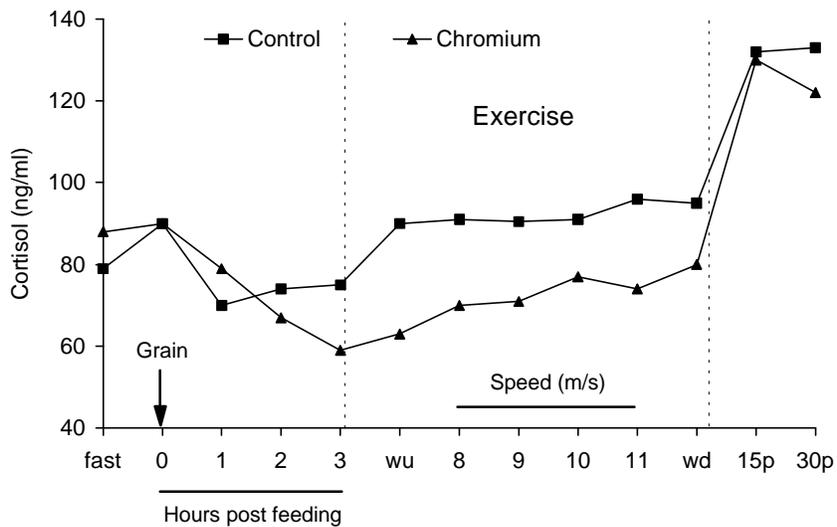


Figure 4 Plasma cortisol (ng/ml)

Discussion

Supplementation with an organic form of chromium affected insulin response to a grain meal in these exercised horses. This response is consistent with findings in humans (Anderson *et al.*, 1991a) and pigs (Evoock-Clover *et al.*, 1993) where chromium

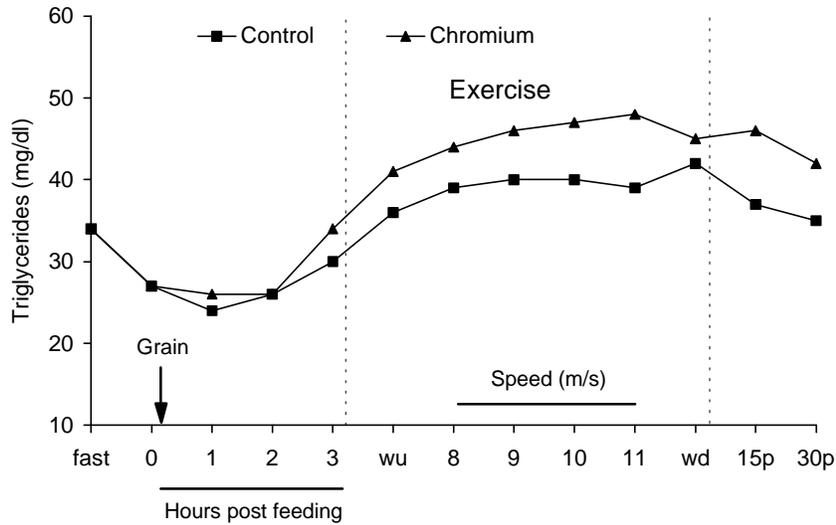


Figure 5 Plasma triglycerides (mg/dl)

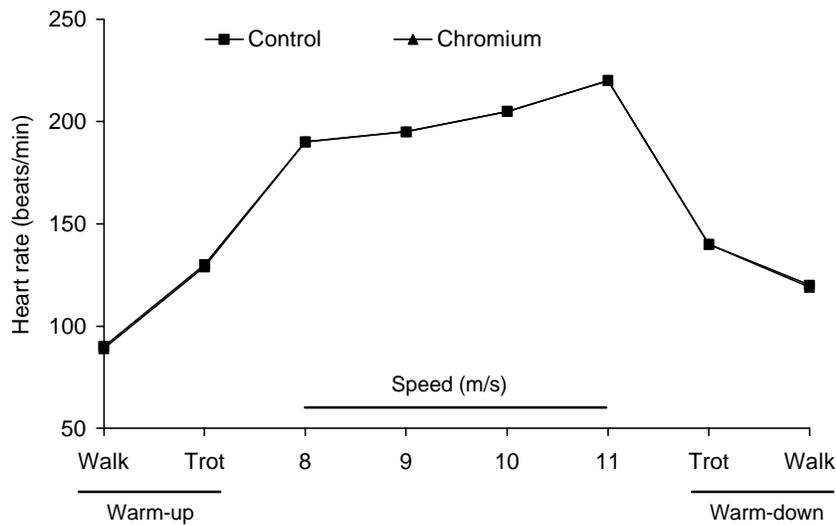


Figure 6 Heart rate (beats per minute)

supplementation increased glucose tolerance and insulin sensitivity. Trivalent chromium, as a constituent of glucose tolerance factor (GTF), is thought to facilitate interactions between insulin and insulin receptors on target tissues such as muscle and fat.

Plasma cortisol was also affected by chromium supplementation. Cortisol concentrations were lower in the CHROM group 3 hours after feeding and during exercise and this effect may have also been related to differences in insulin status. Cortisol acts antagonistically to insulin and this may be the underlying metabolic role

of cortisol in stress (Munck *et al.*, 1984). The function of cortisol may be to prevent insulin from causing dangerous hypoglycemia. In a previous study with trained Thoroughbreds (Pagan *et al.*, 1994), high insulin levels post feeding were associated with high cortisol production.

Elevated triglycerides in the CHROM group during and after exercise may have also been related to insulin production. Insulin inhibits lipid mobilization from adipose. The increase in triglycerides in the CHROM group may have been the result of high lipid mobilization during exercise. Free fatty acids mobilized during exercise that were not taken up and oxidized by the working muscle may have been used to resynthesize triglycerides in the liver.

Plasma lactate was lower after the fastest step of the SET in the chromium supplemented horses. The reason for this decrease is unknown, but may be related to a change in carbohydrate and lipid metabolism brought about by a reduction in insulin production or increase in tissue insulin sensitivity. Since lactate accumulation has been implicated as a contributing factor to fatigue during strenuous exercise, this reduction in lactate accumulation can be interpreted as being beneficial for the performance horse. The horses used in this experiment had been in training for several months before the start of this experiment and they continued to exercise throughout the study. Research in humans has shown that chromium excretion is related to exercise intensity (Anderson *et al.*, 1991b). This may explain why these horses responded to chromium supplementation while untrained, sedentary horses in a subsequent study (Pagan, unpublished data) did not. Chromium is a nutrient, not a drug. Therefore, it is reasonable to only expect a metabolic response in horses that are deficient in chromium. More research is needed to determine which factors affect chromium status in horses and what levels of supplementation are effective.

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