Final report from project:

Effects of housing system on recovery after exercise in horses

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Aim and hypothesis of the study

The aim of the project was to examine whether recovery after competition like exercise was affected by housing system (conventional one-horse box system or active group housing system). Our hypothesis was that horses kept in a housing system where they can move freely in groups would not show delayed recovery compared to horses kept in box stalls for most of the day.

Relevance for the horse industry

The aim of horse management is to keep horses healthy, ensure good animal welfare and performance. Healthy horses can be trained and schooled without unwanted interruptions in their training schedule and do not require expensive veterinary treatments. However, there is a concern that more animal-friendly housing systems than commonly used today may affect competition performance negatively.

Background

Most horses in Sweden (Jordbrukverket 2012) and other countries (Bachmann and Stauffacher 2002, Petersen et al. 2006, Henderson 2007, Hotchkiss et al. 2007) are currently housed in individual box stalls in stables in the same way as they have been for the past hundred years. Housing a horse in a small box stall obviously limits its scope for free movement. It is common practice to bandage the legs of horses stabled in conventional box stalls overnight, in order to minimise swelling of their legs. However, bandaging is a way of treating a problem that is, at least partly, caused by reduced blood circulation, owing to lack of physical activity in the enclosed housing space. Horses stabled in active group housing seem to move twice as much as horses stabled in box stalls (Gullbrandsen 2014) and therefore it is of interest to investigate how these different housing systems affect recovery. It is also known that the level of physical activity after exercise can affect recovery of e.g. plasma lactate concentration (Marlin et al. 1987). Keeping a horse in a box stall also limits its scope for social interaction with other horses and its possibility for feed seeking behaviour and foraging. From a horse management perspective, there are thus several reasons for evaluating alternative housing systems to the conventional box stall, in order to improve the scope for movement, social contact and foraging.

One reason why few horse housing systems have been modernised may be that many horse keepers are reluctant or unable to invest in new systems, but there may also be a fear that horses will not perform as well in competitions if kept in a housing system allowing more freedom of movement. To our knowledge, there is no scientific proof to justify this fear, but to encourage horse keepers and horse owners to change horse housing system they need proof that horse performance will not be affected negatively. One way to measure this is to study recovery after competition, since recovery rate is limiting for when a horse can be trained and competed again.

Methods and expected outcomes

Eight Standardbreed trotter geldings in training at Wången (National Training Centre for Education in Trotting and Icelandic horses) were included in our study. The study was performed in a cross-over design with 21 days on each of two treatments, consisted of housing in active group housing and housing in box stalls.

On two occasions per treatment, the horses were transported to Östersund race track where they performed an exercise test designed as a race. Heart rate was measured and blood samples were taken at rest, directly after the exercise and during recovery until 48 hours after the race. We analysed plasma concentrations of lactate in these blood samples to monitor blood lactate disappearance during recovery.

To evaluate effects on horse locomotion, objective asymmetry registrations were performed with a Lameness Locator (Equinosis, USA) and swelling around the joints was measured with a sliding calliper and measuring tape. Plasma concentrations of ASAT (aspartate aminotransferase) and CK (creatine kinase) was analysed as indicators of muscle damage.

Feed intake also affects recovery, since it must be sufficient to compensate for energy and fluid losses. Previous observations (Connysson unpublished) on the Standardbred trotters at Wången indicated that horses have better appetite and higher body condition scores when housed in active group housing than in box stalls. Negative energy balance can be detected by evaluating body condition score and measuring body weight over time. Metabolic markers such as non-esterified fatty acids (NEFA) and urea can also be used as indicators of negative energy balance in horses, i.e. whether they are using body fat and protein for energy metabolism. We therefore analysed plasma NEFA and urea concentrations.

The decline in body weight in horses directly after heavy exercise is mainly due to faecal and sweat losses (water and electrolytes). By measuring body weight and changes in total plasma protein concentration before and after exercise, we can study how fluid balance is affected by housing system. Thus we analysed plasma protein concentrations (TPP) and recorded body weight.

Measurements, sampling, and analysis

During ET days, blood samples were collected via a catheter inserted in the vena jugularis. A local cutaneous anesthetic was administered approximately one hour before the first blood sampling. Blood samples were collected in 6 mL lithium-heparinized tubes and kept on ice until centrifuging, after which the plasma was frozen (-20°C). Blood samples were collected at rest in the stable (Rest), at the race track 1 minute after the finish line (FL) and after 10, 60, 180, 240, 300, 360, and 420 minutes of recovery (R10, R60, R180, R240, R300, R360, and R420). At 20 and 44 hours after the ET (R20h and R44h), blood samples were collected by venipuncture from the jugular vein.

Total plasma protein concentration (TPP) was measured on all plasma samples in the field with a handheld refractometer (Atago, Tokyo, Japan). Plasma lactate concentration was analyzed in samples Rest, FL, R10, R60, R180, and R420, using an enzymatic (L-lactate dehydrogenase and glutamate-pyruvate transaminase) and spectrophotometric method (Boehringer Mannheim/R-Biopharm, Darmstadt, Germany), with intraassay coefficient of variation (CV) 2.2% in this study. Plasma NEFA concentrations were analyzed in samples taken at Rest, FL, R10, R60, R180, R240, R420, R20h, and R44h with quantitative determination using an enzymatic colorimetric method (Wako Chemicals GmbH, Neuss, Germany), with intraassay CV 1.8% in this study. Plasma urea concentrations were analyzed with a spectrophotometric method (Urea Assay Kit, Cell Biolabs Inc., San Diego, USA), with intraassay CV 1.3% in this study. Plasma aspartate amino transferase (AST) and creatine kinase (CK) concentrations were analyzed using an automated clinical chemistry analyzer (Abbott Architect c4000, Abbott Park, IL, US) with commercial reagents from Abbott.

Statistical analysis

Analysis of variance was performed with the MIXED procedure in SAS (version 9.4; SAS Institute Inc., Cary, NC), using an autoregressive (AR(1)) structure. Plasma sample results were pooled into race (FL and R10), recovery 3-7 h (R180-R420), and recovery 20-44 h (R22h and R44h).

Values are presented as least square means with the pooled standard error of the mean (SEM). Differences were considered statistically significant at $P<0.05$.

RESULTS

Feed intake, body weight and energy balance

Forage intake was higher in the free-range system (FR) than in boxes (B) (FR: 48 vs B: 39 kg/four horses, SEM 1.7 kg ($P=0.003$)) and while in FR, horses also showed a tendency for higher BW (FR: 505, B: 500, SEM 13 kg ($P=0.07$)). There was no difference in BCS between the housing systems (FR: 4.8, B: 4.7, SEM 0.4 ($P=0.93$)).

Short-term recovery (3-7 h)

HR, plasma CK, AST, NEFA, urea, and TPP concentrations all increased from rest to race, and recovery was therefore necessary. There was a tendency during 3-7 h recovery for higher HR in FR compared with B (47 vs. 43, SEM 2 beats/min ($P=0.100$)). The rate of recovery of plasma CK, AST, NEFA, urea, and TPP concentrations was not different between the treatments. The different housing systems did not significantly affect plasma CK, AST, NEFA, urea, or TPP concentrations during 3-7 h recovery (Table 1).

Table 1. Plasma concentrations during recovery of creatine kinase (CK), aspartate amino transferase (AST), NEFA, urea and total plasma protein (TPP) in Standardbred horses kept in free-range group housing (FR) or box housing (B). Race = finish line and 10 min of recovery. SEM = standard error of the mean.

Variable	Sample	FR	B	SEM	P-value
Plasma CK (ukat/L)					
	Rest	1.6	1.6	0.2	1.000
	Race	2.8[a]	2.8[a]	0.2	1.000
	3-7 h recovery	2.1[a]	2.1[a]	0.1	1.000
	20-44 h recovery	1.7	1.5	0.2	1.000
Plasma AST (ukat/L)					
	Rest	4.1	4.5	0.3	1.000
	Race	5.1[a]	5.6[a]	0.3	1.000
	3-7 h recovery	4.5[b]	4.8[b]	0.3	1.000
	20-44 h recovery	4.5[b]	4.7	0.3	1.000
Plasma NEFA (mmol/L)					
	Rest	0.27	0.22	0.05	1.000
	Race	0.43[a]	0.44[a]	0.04	1.000
	3-7 h recovery	0.23	0.22	0.04	1.000
	20-44 h recovery	0.16[a]	0.26	0.04	0.043
Plasma urea (mmol/L)					
	Rest	5.0	4.6	0.3	0.370
	Race	5.2[b]	4.9[a]	0.3	0.593
	3-7 h recovery	5.6[a]	5.3[a]	0.3	0.578
	20-44 h recovery	4.8	4.7	0,3	1.000
Total plasma protein (g/L)					
	Rest	59.4	60.6	1.0	1.000
	Race	70.1[a]	70.8[a]	0.8	1.000
	3-7 h recovery	60.9	62.1	0.8	0.599
	20-44 h recovery	61.9[a]	62.7[b]	0.8	1.000

[a]Significantly different ($p<0.05$) from Rest. [b]Tendency for significant difference ($p\leq0.09$) from Rest.

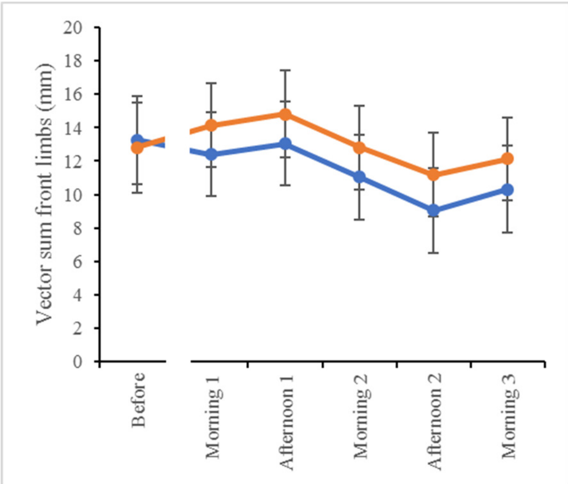
Long-term recovery (20-44 h)

Plasma NEFA was lower at 20-44 h of recovery than before exercise (Rest) in FR (*P*=0.022) but not in B (Table 1). Plasma NEFA was also lower in FR horses than in B horses during 20-44 h of recovery (Table 1). Housing systems had no significant effect on plasma CK, AST, urea, or TPP concentration during 20-44 h of recovery (Table 1).

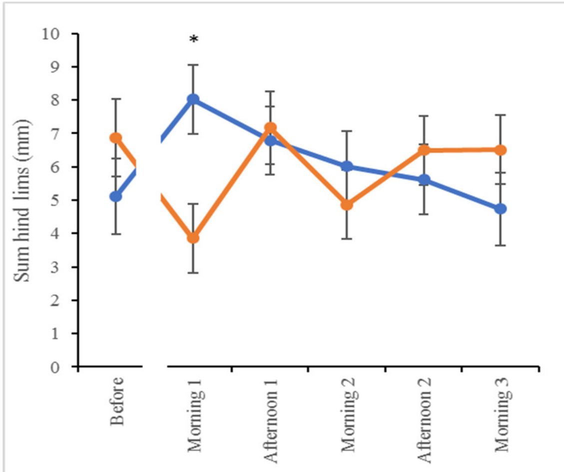
General effects on movement apparatus

Overall circumference and diameter of hind fetlock region were lower in FR than B (26.3 vs. 26.7 mm) SEM 0.4 (P=0.045), 4.9 vs. 5.1 SEM 0.9 cm (P=0.017), respectively). Neither were there any overall effects of FR compares to B on head VS (11.5 vs. 13.0 mm SEM 2.1), sum pelvis (6.0 vs. 6.0 mm SEM 0.7), hook joint range of motion (50.1 vs. 50.4 degrees SEM 1.0), carpus joint range of motion (25.2 vs. 24.7 degrees SEM 1.7) or MNT (278 vs. 282 kPa SEM 30).

A



B



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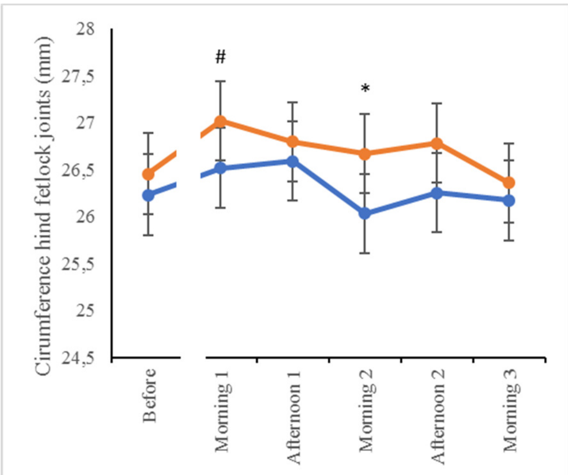

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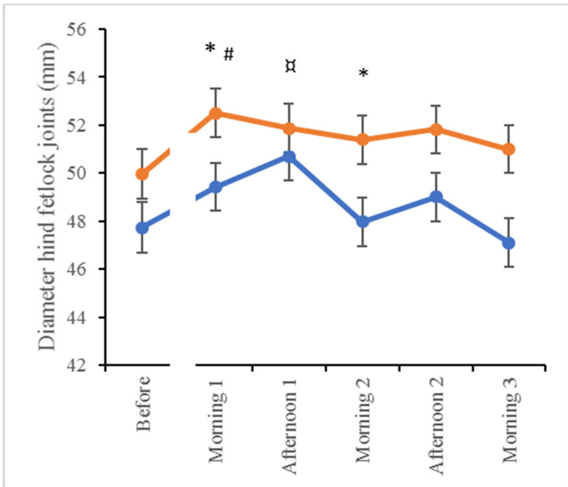

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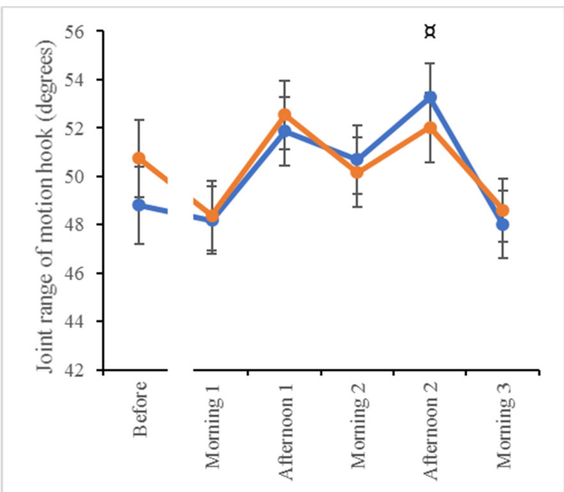

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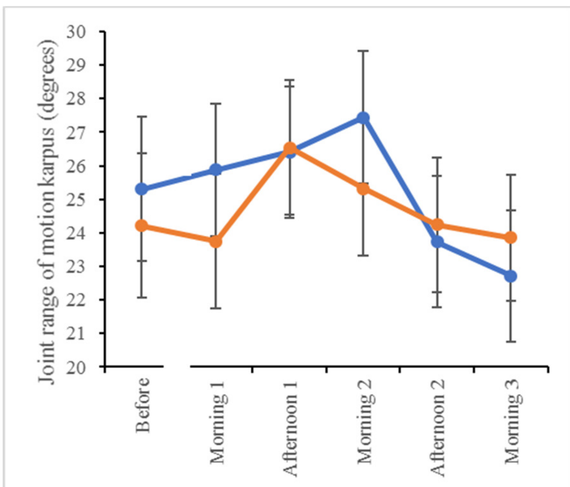

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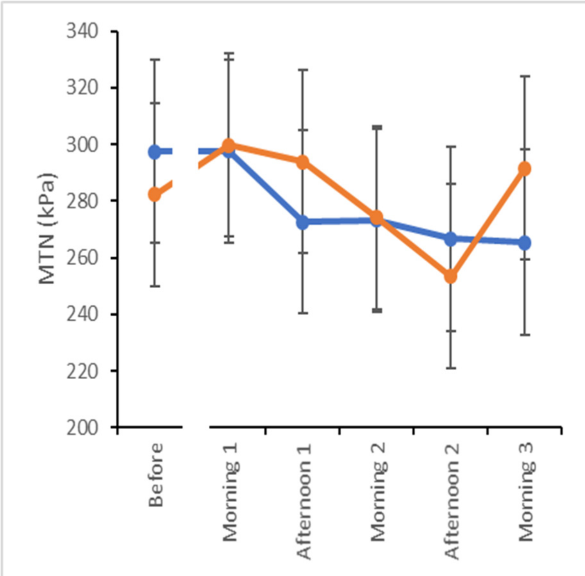

Figure 1. Movement symmetry head (A), movement symmetry pelvis (B), circumference of fetlock joints (C), diameter of fetlock joint (D), joint range of motion hook (E), joint range of motion in right carpus (F), mechanical nociceptive threshold (MNT) (G) in horses housed in box stall (red) or an active group housing (blue). *Significant ($P<0.05$) difference between housing systems. ¤Significantly ($P<0.05$) different from Rest values in active group housing. #Significantly ($P<0.05$) different from Rest values in box stall housing.

Discussion

The results obtained here indicate that there is little or no difference in short-term metabolic recovery in horses kept in the free-range and box stall housing systems evaluated. The lack of difference in the short-term perspective (HR, TPP, and metabolic responses) was probably due to events in the immediate recovery period after exercise (i.e., 1000 m slow-down trot, walk, and road transport back home) being the same in both treatments. It has been shown previously that, during the first 30 min after intense exercise, lactate removal can be increased two-fold by light exercise (Marlin et al., 1987). The lack of difference in NEFA, urea, and TPP responses indicate that water and feed intake were similar in the short-term recovery period.

The NEFA levels were very low during long-time recovery in FR horses, even lower than before the ET. This indicates quick and efficient recovery of energy balance by horses in this housing system. This finding is also supported by the higher feed consumption observed in the FR housing system.

The results obtained in this study also indicate that there may be adverse effects in the response of the locomotion apparatus to a box-stall housing system. The hind fetlock region was consistently more swollen (increased circumference and diameter) in B horses during the days following racing, indicating more swelling of the joint region, although the numerical differences were small. The importance of this remains to be evaluated. A common practice in racing stables with box-housed horses is to put bandages and liniment on the distal parts of the legs (from carpus/hook to pastern) to prevent or reduce swelling. The effects of bandages and liniment on effusions is not known, but the present study actually presents an option to reduce effusions by allowing more free movement.

Both AST and CK were in the normal range for healthy athletic horses (Hodgson et al., 2014) during all measurements. Although AST and CK were elevated after the ET, both Rest values and race values were lower than reported previously after a real race in Standardbred trotters (Pösö et al., 1983), indicating non-significant muscle damage. Combined with the lack of post-exercise response in MNT in the back, this indicates that the ET in the present study did not cause any measurable DOMS in the area evaluated. However, the ET in this study resulted in HR and plasma lactate values similar to those reported in real races (Roneus et al., 1999). Thus the lack of post-exercise response in the horses was somewhat surprising, but indicates that the horses in the study were well prepared for the task.

Conclusion

In conclusion, this study showed that a free-range housing system did not delay recovery. In contrast, it had positive effects on appetite and recovery of energy balance compared with housing in a traditional box stall system and abolished post-race joint swelling. However, the importance of swelling observed around distal joints for long-term orthopedic health needs further investigation.

Plan for communicating results

The results will be published in an international peer-reviewed journal and presented at national and international conferences in order to communicate the results to other scientists. To reach out to practitioners, the results will also be published in popular science publications (*HästSverige*), presented at lectures and conferences (*Hippocampusdagarna, breed evaluations*) and published in horse sports magazines (*Ridsport*, *Travronden*, *Islandshästen*).

The Wången Centre educates future professional trotter (and gallop) trainers, care takers, farriers and Bachelor's degree students in Equine Science, offering unique opportunities to spread new knowledge to practitioners. Wången is also active in spreading information through websites and social media. In addition, Anna Jansson and Marie Rhodin teach at SLU and can thereby spread new knowledge to undergraduate students within the agronomy, animal nursing, ethology, animal welfare and veterinary programmes at SLU.

The project has been communicated:

Wången web site (http://wangen.streamingbolaget.se/video/177269/link?autostart=1)

Wångens tidning that was distributed to all Travronden subscibers (https://wangen.se/om-oss/wangens-tidning-1-2018/)

Hippson (https://www.hippson.se/nyheter/malin-connysson-forskar-for-hastarnas-basta.htm)

Malin Connyssons thesis (https://pub.epsilon.slu.se/15291/)

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