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Behavioral and physiological responses of horses to initial training: the comparison between pastured versus stalled horses

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Abstract

Horses kept in stalls are deprived of opportunities for social interactions, and the performance of natural behaviors is limited. Inadequate environmental conditions may compromise behavioral development. Initial training is a complex process and it is likely that the responses of horses may be affected by housing conditions. Sixteen 2-year-old Arabian horses were kept on pasture (P) ($n = 8$) or in individual stalls (S) ($n = 8$). Twelve horses (six P and six S) were subjected to a standardized training procedure, carried out by two trainers in a round pen, and 4 horses (two P and two S) were introduced to the round pen but were not trained (C; control). On sample collection day 0, 7, 21 and 28, behavior observations were carried out, blood samples were drawn and heart rates were monitored. Total training time for the stalled horses was significantly higher than total time for the pastured horses (S: 26.4 ± 1.5 min; P: 19.7 ± 1.1; $P = 0.032$). The stalled group required more time to habituate to the activities occurring from the start of training to mounting (S: 11.4 ± 0.96; P: 7.3 ± 0.75 min; $P = 0.007$). Frequency of unwanted behavior was higher in the stalled horses (S: 8.0 ± 2.0; P: 2.2 ± 1.0; $P = 0.020$). Pastured horses tended to have higher basal heart rates on day 0 (S: 74.7 ± 4.8; P: 81.8 ± 5.3 bpm; $P = 0.0771$). While the physiological data failed to identify differences between housing groups, the behavioral data suggest that pasture-kept horses adapt more easily to training than stalled horses.

Keywords: Horses; Housing; Training; Behavior; Stress; Cortisol; Welfare

1. Introduction

Horses kept in stalls are deprived of opportunities for social interactions and the performance of natural behaviors is limited (Hogan et al., 1988). The size and design

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of box stalls is variable. They are typically 9 or 13 m^2 in size, possibly with a small window and/or dividing bars between stalls (Evans et al., 1990). Housing horses in stalls offers a different experience than what is present in a natural, pasture-like environment. Free-range horses have a structured social environment. Harem bands, averaging five to seven horses, are typically comprised of mares, a few yearlings and foals and one stallion (Kirkpatrick and Francis, 1994). These cohesive bands may roam over vast areas of land and stay together even in the absence of the stallion. An inadequate social environment may impair behavioral development in social species (Mendl and Paul, 1991). The behavioral deprivation experienced by horses housed in individual stalls may be detrimental to their welfare.

The social environmental conditions to which a horse is exposed may affect its ability to respond to challenging situations, altering its behavior, physiology and compromising their welfare. If the environment negatively affects the animal's learning ability, trainability, along with the value of the horse, may decrease. Environmental variables include, but are not limited to, nutrition, trainer experience, degree of handling, temperature, lighting and housing. The environmental condition a horse is exposed to may affect its learning ability. Stalling weaned foals altered their behavior qualitatively and quantitatively when compared to foals weaned in a paddock (Heleski et al., 1999). In this study, paddock-housed foals spent the majority of their time standing in close contact with the other horses, interacting with the horses or eating. The stalled horses could not perform some of the behaviors observed in the paddock-housed foals (i.e. grazing, social interactions). In addition, the stalled foals performed more uncommon behaviors such as licking, chewing and kicking the stall walls. Weaving, cribbing and stall walking are behavior abnormalities linked to stalling horses (Kiley-Worthington, 1990).

If the environment causes the horse to make costly (e.g. fitness impairment) adjustments in behavior and physiology, the housing situation may be deemed as stressful (Broom and Johnson, 1993). Physiological measures such as plasma cortisol (Boulton et al., 1997) and heart rate (Baldock and Sibly, 1990) have been associated with activation of the hypothalamus–pituitary–adrenal axis system, which is triggered during stressful situations in animals.

Training a young horse for the first time requires the elimination of fearful responses towards the trainer and the habituation of the animal to novel situations. In addition, during initial training, horses are exposed to new tasks. Humane training protocols have been developed using the "round pen technique." Initial training using the round pen is based on the understanding of the behavior of the horse, minimizing the stress associated with training. Horse trainers, such as John Lyons, Ray Hunt and Monty Roberts, have used this technique. The frequency and duration of behaviors that occur during a training session using a round pen have never been documented. Moreover, no one has examined how housing experience may help or hinder adaptation by a horse during training. We investigated the impact of housing on the ability of horses to acclimatize more readily to initial training. The objective of this study is to determine if housing conditions may have an effect on behavioral and physiological measures in horses that are subjected to a standardized training procedure.

2. Materials and methods

2.1. Animals and housing

Sixteen Arabian yearlings comprised of castrated males ($n = 11$) and intact females ($n = 5$), with an average age of 18.6 months (range 16.6–19.9) were used in this study. Average weight for the stalled (S) and pastured (P) horses at the start of the project was 349 ± 10 and 342 ± 10 kg, respectively. The horses were born and housed at the Michigan State University Horse Teaching and Research Center (MSUHTRC).

The horses were randomly assigned to three treatment groups according to housing, training and age: pasture with training (P; $n = 6$) or stall with training (S; $n = 6$) and a control group with no training (C; $n = 4$). The C group was assigned into the P ($n = 2$) or S ($n = 2$) treatment group. Two weeks into the experiment, due to an accidental injury, one of the P horses was removed from the project. Therefore only five horses were in the P group for the remainder of the study.

Pastured horses were housed on approximately 29,166 m^2 of land with a water dispenser, hay trough and grain trough in the field. The 10 m^2 box stalls used for housing had dividing walls constructed with wooden panels on the bottom and steel guards on the top, allowing limited social interaction between the horses. Each stall had a window along with a hay trough, grain bucket and water bucket. Stalls were bedded with wood shavings or straw.

2.2. Animal management

The study was conducted during the winter when minimal nutrients were available from pasture grazing. All treatment groups were fed a diet recommended by NRC (1989) for long yearlings and 2 years-old. Each horse was fed 1.8 kg per day of a commercial concentrate (Strategy™, Purina Mills, Lansing, MI) divided into two equal feedings, at 06.00 and 18.00 h.

2.3. Trainers

Two trainers were involved in the training procedure. The novice trainer (female, 50.0 kg) was a graduate student with no prior experience in the initial training of horses. The second trainer had 10 years of horse experience (male, 62.3 kg). In the interest of human safety, horses that were subjectively determined as "easier" to train were assigned to the novice trainer. On day 0 of training, the experienced trainer trained eight horses (four P and four S) while the novice trainer trained four (two P and two S). For the remainder of the study, including the loss of the pastured horse, the experienced trainer trained five horses (two P and three S) while the novice trainer trained six (three P and three S).

2.4. Equipment and facility

2.4.1. Training arena

All training sessions were conducted at the MSUHTRC facility. Training took place in an indoor round pen approximately 15 m in diameter. The flooring material throughout the arena was a mixture of sand and clay.

2.4.2. Training tack

Equipment used for initial training of the horses included a lead rope, halter, saddle pad, bridle with a jointed snaffle bit and reins. The lead rope was 1.8 m long and was attached to a ring on the halter with a clip. In this study, the lead rope was used for a variety of purposes including controlling the horses while walking and standing, encouraging forward movement and as reins, for the first day of training. The halter is designed to fit on the horse's head so the trainers can control the horses as they lead them. The saddle pad is placed on the horse's back before the saddle. The pad is placed near the withers and extends down towards the center of the shoulder (C.H.A., 1996). The purpose of the saddle pad is to prevent chafing or discomfort from the saddle while riding. Both trainers used a western style saddle.

Bridles are used for steering or directing the horses. The snaffle bit allows the trainer to control the horses through pressure (C.H.A., 1996). The snaffle bit consists of two rings joined by a smooth mouthpiece, which is jointed in the center. The snaffle bit applies pressure on the mouth of the horses. Reins are run through the rings of the bit and are controlled by the trainer.

2.4.3. Video observations

Four cameras (Panasonic, WV 330), fitted with wide-angle lenses, were used to record the entire round pen during the training sessions. All horses were videotaped on training days 0, 7, 21 and 28 using continuous recording. Video cameras were wired to a multiplexer with split mode capability (Panasonic, WJ 410) and recorded into a VCR (Panasonic, AG 6730), allowing for simultaneous viewing on all four cameras.

2.4.4. Training procedure

Prior to the start of the experiment, a pre-training period occurred for 84 days. During this time, pastured horses were given free access to exercise and the stalled horses were walked daily, for one hour, on a mechanical walker. Training occurred 5 days a week, for 28 days, with sample collections occurring on days 0, 7, 21 and 28. On off-days, as their stalls were cleaned, stalled horses were exercised, 1 h a day, on a mechanical walker.

The objective for the first day of training was to habituate the horse to the trainer, having a saddle on their back, being mounted, being ridden and being dismounted. Depending on the procedure, the main objective for each technique was to either have the horse stand still or move forward when asked. All techniques were performed on the left and right sides of the horses. Training was divided into two periods, groundwork and riding. The groundwork period encompassed all the training procedures that occurred up to the first mount. The riding period began once the trainer was mounted on the horse and ready to ride.

2.4.5. Groundwork

Training began with suppleness exercises that were accomplished by gently applying pressure on the lead rope that was attached to the halter. Suppleness training was performed on both sides until the horse would slightly turn towards the pressure. Upon acclimating to the pressure, each horse was released in the round pen. Once the horse was released, the trainer would move towards the hindquarters of the horse while swinging the arms and/or lead rope, which would generally cause the horse to run. When running, the horse would not typically look at what was chasing it. Eventually the horse would glance at the stimulus, in this case the trainer, and at that moment the trainer would stop moving towards the horse's hindquarters and swinging the arms and/or lead rope. In this way an association between the behavioral response (looking at the trainer) and the behavior of the trainer (stopping swinging arms/rope) was attained.

The trainer then approached the horse, attached the rope to the halter and resumed suppleness exercises. Again, once acclimatized to the pressure on both sides, a new training procedure began.

The horses were habituated to the equipment by gently tossing the lead rope, saddle pad and saddle repeatedly onto the horse's back until the horse stood still (''sacking''). The lead rope was also tossed and/or rubbed along the body of the horse to accustom it to stimuli in those areas. The objective of this habituation was to get the horse accustomed to the tack so that it would stand still when the equipment was presented. Habituation training was performed for the saddle pad and for the saddle. Once the saddle and pad were placed on the horse's back and the horse was standing still, the trainer tightened the girth. With the saddle on, the horse was once again released into the round pen. This procedure continued with an additional tightening of the cinch until a subjective decision based on how the saddle was lying on the back of the horse was made by the trainer to end this procedure. The trainer then approached the horse and snapped the rope to the halter. Suppleness exercises often occurred again before the final procedures were performed for mounting.

Following the saddling procedure, the trainer placed a foot in the stirrup while holding the rope, slightly turning the horse's head. Turning the horse's head added a safety measure for the trainer. In this position, the horse was semi-restricted to moving only in a small circle. The trainer stood with a foot in the stirrup until the horse remained still. Using the same procedure, the trainer would next place a foot in the stirrup and add body weight by hoisting and laying the upper body onto the back of the horse. Once the process was done on each side and the horse was standing still, the trainer would lift the free leg over the horse and gently lower the body onto the saddle. The trainer was now mounted on the horse. Many of the groundwork procedures were not performed by days 21 and 28 of training, when the trainer would immediately mount the horse and begin the riding portion of training.

2.4.6. Riding

Once the trainer had mounted the horse, the riding period began. The primary objective during this period was to obtain forward motion of the horse. Using hands, legs and body weight as cues at the walk, trot and canter, the trainer encouraged the horse to move forward. For the remainder of the study, horses were walked, trotted and cantered.

2.4.7. Control group

The control group horses experienced the same protocol as the trained group without the actual training procedures. Control horses were led from their respective housing situations but instead of training, horses were released into the round pen and allowed to roam freely the environment for 30 min. To protect the video cameras, a human observer was asked to stand behind a gate in the arena and have no contact with the horses.

2.4.8. Data collection

2.4.8.1. Blood sampling. Blood samples were collected via jugular puncture, four times per horse at days 7, 14, 21 and 28 of training. Samples were collected: once before entering the round pen; at the completion of training; 15 min post-training (pt); 75 min post-training. Samples were pipetted into EDTA and heparin tubes and immediately placed on ice for 5 min. Samples were centrifuged at $1340 \times g$ for 15 min at 4 °C.

2.4.9. Heart rate monitors

The Polar Vantage NV™ (Polar Electro Oy, Kempele, Finland) wristwatch was used to monitor heart rates in the horses. The pastured group was removed from the pasture and led into a stall one h prior to training to install the monitors. Heart rates were recorded and data were stored in the Polar Vantage NV™ wristwatches continuously beginning 60 min before the horse entered the round pen until 75 min post-training. Heart rate data were downloaded from the wristwatches using the Polar Advantage Interface™ and stored in the Polar Precision Performance™ Software for Windows (Version 2.0) for future analysis.

2.4.10. Data analysis

2.4.10.1. Behavior data. Preliminary analysis of the behavior data was accomplished using the Observer™ (Noldus Information Technology Inc., Sterling, VA) program. Behavior categories and definitions can be found in Table 1a–d.

Table 1
Behavioral definitions

Horse and trainer behavior categories used in study for the groundwork training period	
(a) Trainer categories	
Chase	Trainer encourages the horse to move forward by positioning the body towards the hindquarters of the horses while swinging lead rope and/or arms
Sacking with saddle pad	Pad is gently tossed onto the horse's back and removed
(b) Horse behavior categories and definitions that occurred during the riding portion of training	
Head/neck extension up	While riding, horse's neck is stiffened and head is extended upward
Head/neck extension down	While riding, horse's neck is stiffened and head is extended downward
Head/neck extension straight out	While riding, horse's neck is stiffened and head is extended straight out
(c) Behavior categories and definitions that occurred during both the groundwork and riding periods of training	
Normal tail	Tail is not elevated nor switching nor clamped.
Bucks and jumps	Horse's four legs are elevated off the ground while the hind legs are extended outward or sideways; also vertical jumps
(d) Descriptions of training periods	
Groundwork	Duration of time between the horse entering the arena without a saddle, until the time the saddle is placed on the horse and cinched
Riding	Riding

2.4.10.2. Cortisol assay. Plasma cortisol samples were processed using a Coat-A-Count® (Diagnostic Products Company®, Los Angeles, CA). All samples were processed in 1 day using the radioimmunoassay protocol procedure recommended by the supplier to minimize variability.

2.4.10.3. Statistical analysis. Behavioral categories were recorded as count data and were analyzed assuming Poisson distribution. Data were normalized using square root transformation ($y = \text{sqrt}(x + 1)$) when the criteria for normality were not observed. A linear model based on the factors of housing (with two levels) and trainer (with two levels) with repeated measures over 4 days was used to analyze the data. This model also allowed for all possible two-way interactions. Least-square means were computed and back-transformed as point estimates and as 95% confidence intervals on the scale of observation.

A linear model based on the factors of housing (with two levels) and the random effect of horse, nested within housing, with repeated sampling time measures over 4 days, was used to analyze cortisol. All two-way interactions between these factors were also included in this model. Least-square means were used for comparing means responses.

All behavioral and physiological data were analyzed using SAS Proc Mixed and Proc Corr. Means were considered highly significant at $P \leq 0.01$ and significant at $P \leq 0.05$ while results showing values of $P \leq 0.1$ were considered trends.

3. Results

3.1. Training times

Overall, stalled horses required a greater amount of time (minutes) to complete the entire training procedure than the pastured horse (S: 26.4 ± 1.5 min; $P = 19.7 \pm 1.1$; $P = 0.032$). Analysis of the housing by day interaction did not reveal a difference on day 0 between the treatment groups. However, on day 7 ($P = 0.081$), day 21 ($P = 0.069$) and day 28 ($P = 0.079$) the stalled group tended to require a greater amount of time to complete training (Fig. 1).

During the groundwork portion of training the stalled group required more time to habituate to the various training procedures (S: 11.4 ± 0.96; P: 7.3 ± 0.75 min; $P = 0.007$). Further analysis revealed no differences between treatment groups on day 0 (S: 28.8 ± 3.3; P: 22.9 ± 2.6; $P = 0.162$) and day 21 (S: 3.5 ± 1.0; P: 1.7 ± 0.8; $P = 0.122$). However, the stalled horses took longer to complete the groundwork portion of training than the pastured horses on day 7 ($P = 0.039$) and a tendency for longer training times was revealed on day 28 ($P = 0.072$) (Fig. 2).

Overall, no effect of housing during the riding portion of training (time interval between mount to dismount) was observed (S: 9.7 ± 1.6; P: 8.5 ± 0.8 min; $P = 0.33$). No differences were observed on day 0 (S: 13.0 ± 2.2; P: 12.8 ± 2.1; $P = 0.162$), day 7 (S: 9.3 ± 1.7; P: 7.3 ± 1.5; $P = 0.176$), day 21 (S: 6.2 ± 1.4; P: 6.9 ± 1.6; $P = 0.656$) or day 28 (S: 10.5 ± 1.8; P: 6.2 ± 1.5; $P = 0.211$) between housing treatments (Fig. 3).

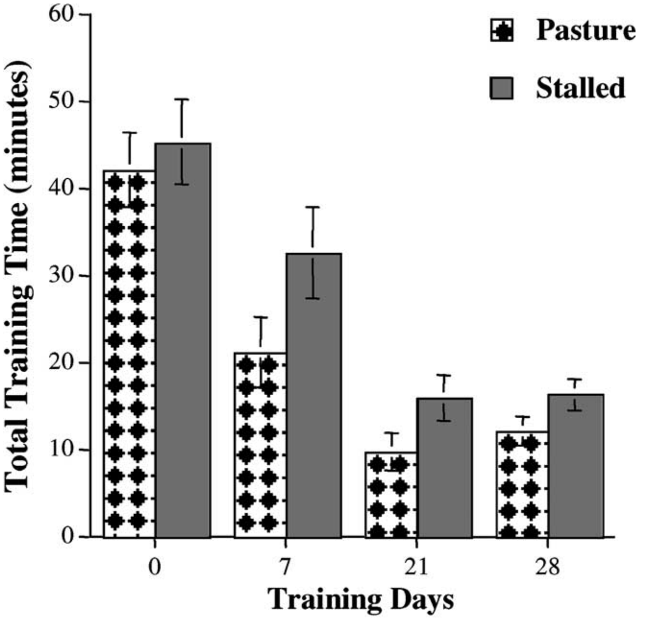

Fig. 1. Differences (mean ± S.E.M.) in total training times between treatment groups on training days. Time began once horses entered the round pen until the trainer dismounted.

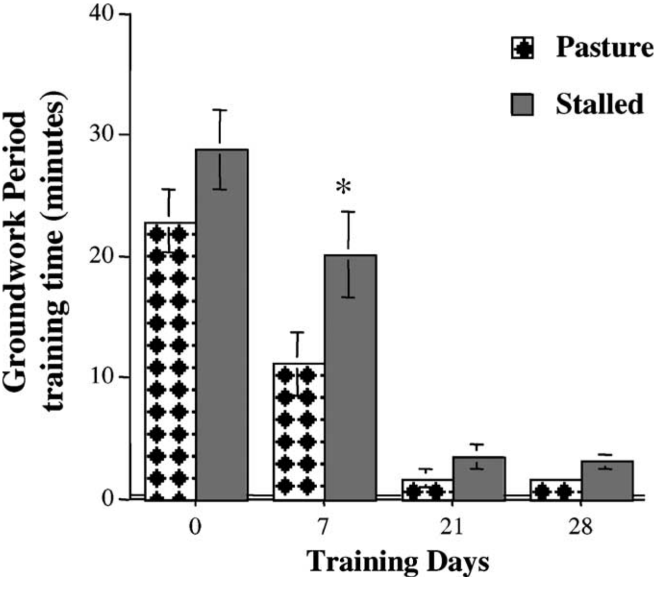

Fig. 2. Latency (mean ± S.E.M.) between the horses entering the round pen until the trainer mounted the horses for the first time, $^{*}P < 0.05$.

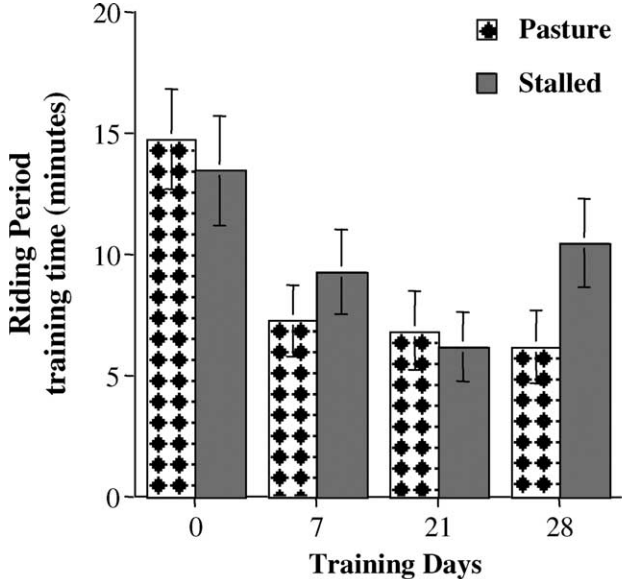

Fig. 3. Latency (mean ± S.E.M.) between the time the trainer mounted the horses until the trainer dismounted, on training days.

3.2. Trainer behaviors towards the horses during groundwork training

Over the entire training period, trainers sacked the stalled horses more times with the blanket compared to the pasture treatment group (S: 23.0 ± 3.5; P: 8.6 ± 2.5; $P = 0.045$). On day 0, trainers sacked the stalled group more times compared to the pastured group before the desired response of standing still was obtained ($P = 0.031$) (Fig. 4).

3.3. Horse behaviors during groundwork training

Housing treatment had a significant effect on display of head and neck extension upward ($P = 0.0008$). Stalled horses extended their head and neck upward more than pastured horses for day 7 ($P = 0.0004$), day 21 ($P = 0.010$) and day 28 ($P = 0.007$) (Fig. 5).

Overall, the stalled horses stiffened their necks and extended their heads straight out during the riding period 8.6 ± 1.3 times while the pastured horses displayed the behavior only 2.2 ± 1.0 times ($P = 0.002$). The stalled group extended their heads and necks during riding more often on day 7, day 21 and day 28 (Table 2).

3.4. Horse behaviors during groundwork and riding portions of training

Overall, the stalled horses bucked and jumped more frequently than the pastured group (S: 8.0 ± 2.0; P: 2.2 ± 1.0; $P = 0.020$). The frequency of bucking and jumping between treatment groups was different on day 7 ($P = 0.003$), day 21 ($P = 0.026$) and day 28 ($P = 0.0001$) (Fig. 6).

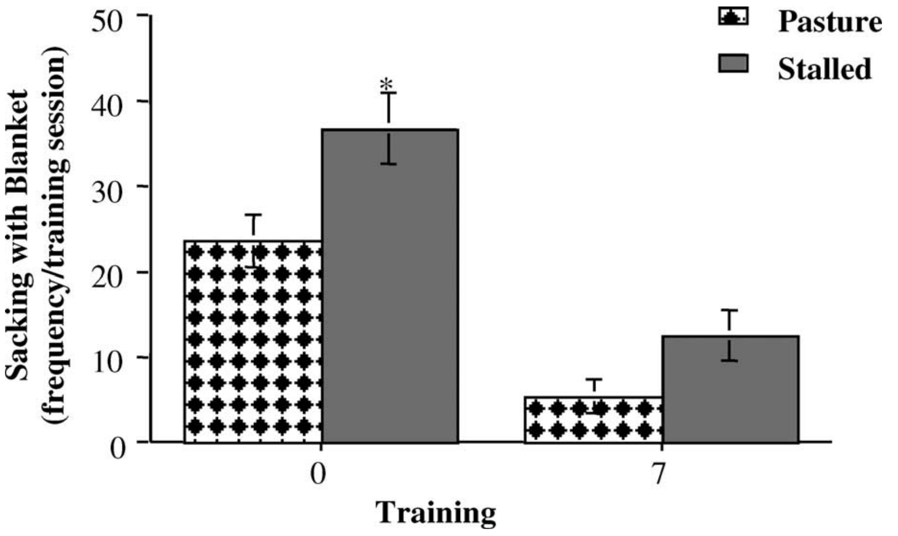

Fig. 4. Frequency (mean ± S.E.M.) of sacking the horses with blanket, during the groundwork period, for training days, $^{*}P < 0.05$.

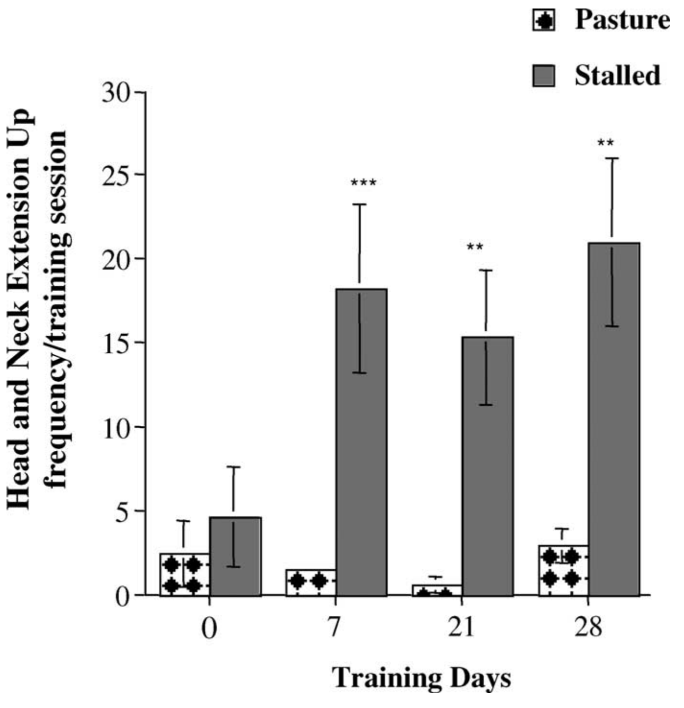

Fig. 5. Frequency (mean ± S.E.M.) of head and neck extension up behavior performed by the horses, during the riding period, over training days, $^{*}P < 0.05$; $^{***}P < 0.001$.

Table 2
Frequency (mean ± S.E.M.) of head and neck extension straight performed by the horses during the riding portion over training days

Day	Housing	Mean ± S.E.M.	P-value
0	Pasture	3.2 ± 2.2	0.187
	Stalled	8.8 ± 3.3	
7	Pasture	2.7 ± 0.3	0.004
	Stalled	11.6 ± 3.0	
21	Pasture	1.1 ± 0.7	0.001
	Stalled	7.0 ± 1.5	
28	Pasture	1.9 ± 1.0	
	Stalled	7.3 ± 1.0	0.07

Overall the duration of time (minutes) of horses carrying a normal tail setting was not affected by housing treatment (S: 8.6 ± 1.7; P: 5.2 ± 1.2; $P = 0.137$). Pastured horses carried a normal tail setting more frequently than stalled horses on day 21 ($P = 0.007$) (Table 3).

3.5. Physiological data

3.5.1. Cortisol

Overall, plasma cortisol concentration was not affected by housing conditions ($P = 0.525$). The effects of days ($P = 0.0001$) and time ($P = 0.0001$) were highly significant. A three-way interaction between housing, time and days failed to reveal a

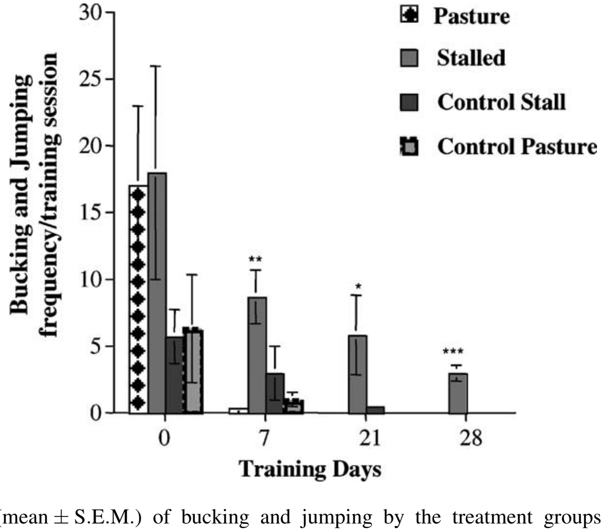

Fig. 6. Frequency (mean ± S.E.M.) of bucking and jumping by the treatment groups over training days, $^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

Table 3
Duration (mean ± S.E.M.) of normal tail setting during the groundwork and riding periods of training, over training days

Day	Housing	Mean ± S.E.M.	*P*-value
0	Pasture	29.2 ± 6.0	0.516
	Stalled	23.3 ± 6.2	
7	Pasture	2.8 ± 2.0	0.288
	Stalled	6.2 ± 3.0	
21	Pasture	1.2 ± 0.8	0.007
	Stalled	7.6 ± 2.3	
28	Pasture	0.96 ± 0.7	0.234
	Stalled	2.8 ± 1.8	

difference ($P = 0.507$). No differences in cortisol concentrations were observed between housing treatments during training days (Fig. 7).

Differences were identified, among combined treatment groups, between total cortisol concentrations and time sampling periods for training days (Fig. 8). Cortisol concentrations at the completion of training were higher than basal cortisol concentrations on day 0 ($P = 0.003$) and day 7 ($P = 0.0001$). No differences were observed on day 21 ($P = 0.623$) and day 28 ($P = 0.339$).

With the exception of day 21 and day 28, cortisol concentrations required >15 min to return to basal levels. On day 0 ($P = 0.0001$) and day 7 ($P = 0.0008$), cortisol levels at the 15 min post-training recovery levels were higher than basal cortisol levels. No differences were observed on day 21 ($P = 0.623$) and day 28 ($P = 0.233$). On day 7 ($P = 0.044$) and day 28 ($P = 0.0006$), 75 min post-training recovery cortisol levels were significantly lower than the basal cortisol levels. On day 0 ($P = 0.689$) and day 21

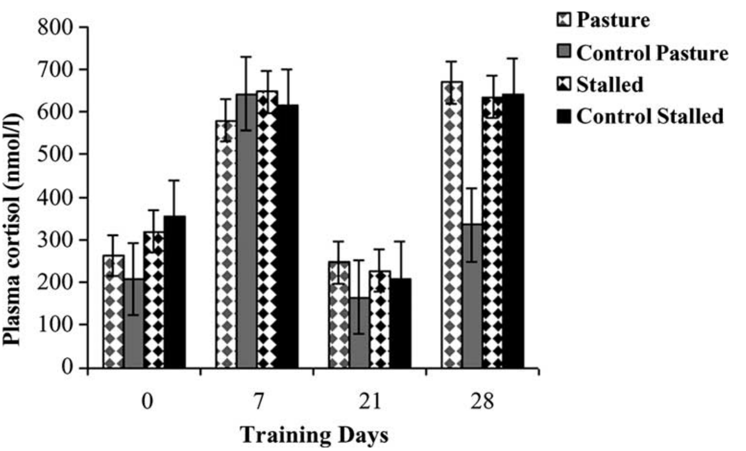

Fig. 7. Plasma cortisol concentrations on training days, for treatment groups.

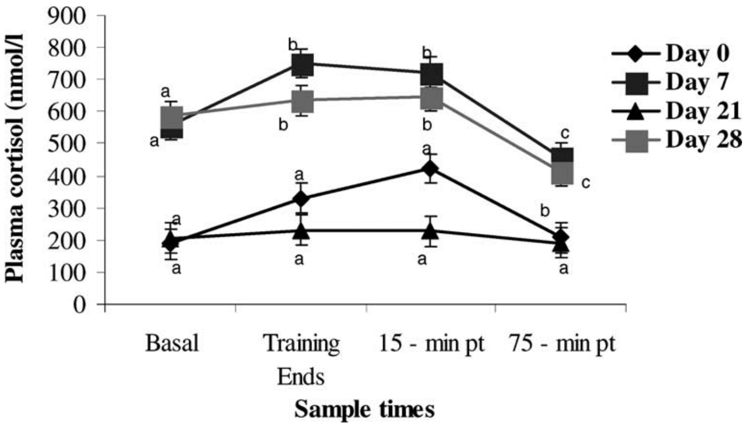

Fig. 8. Plasma cortisol concentration at time sampling periods for training days; a, b and c: sample times with different subscripts differ significantly ($P < 0.05$).

($P = 0.774$) cortisol levels between basal and 75 min post-training samples were similar.

Basal plasma cortisol levels revealed differences between training days. On day 7 and day 28 basal cortisol levels were higher than basal cortisol levels for day 0 and day 21 ($P = 0.001$) (Figs. 7 and 9).

3.5.2. Heart rate

Heart rate was affected by time ($P = 0.0001$) and training days ($P = 0.001$). Stalled horses tended to have a lower basal mean heart rate value when compared to the pastured horses ($P = 0.07$) (Fig. 10). For the other three sampling times, no significant differences were observed between the pasture and stalled treatments.

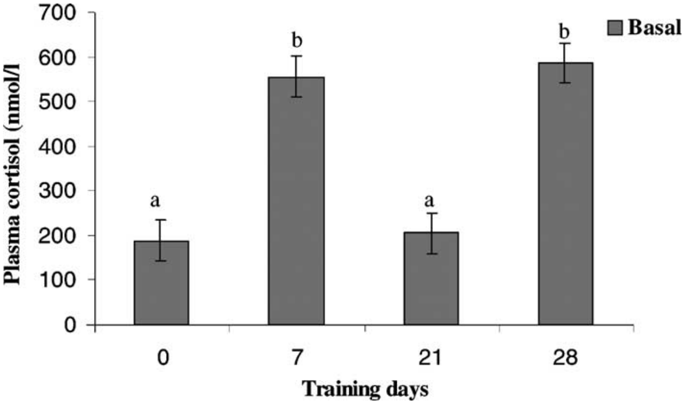

Fig. 9. Basal plasma cortisol concentrations on training days; a and b: training days with different subscripts differ significantly ($P < 0.001$).

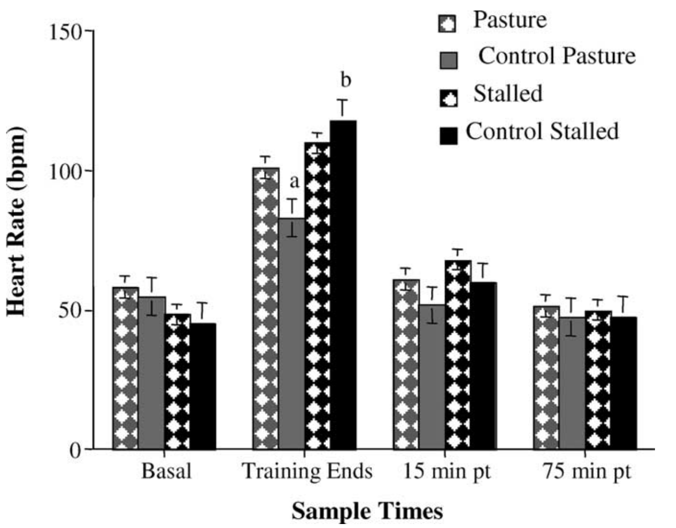

Fig. 10. Heart rate values at sample collection times; a and b sample times with different subscripts differ ($P < 0.001$) (pt = post-training).

4. Discussion

4.1. Training times

Total training time in the arena was, on average, 4 min less for the pastured group. The stalled horses had a tendency to require more time to complete the entire training procedure. On day 0, the novelty of the training procedure may explain the lack of difference between the groups. For the rest of the training schedule, the pastured group tended to complete the training regimen faster than the stalled horses. This tendency may be explained by the differences observed in the behavioral responses to the groundwork training techniques. For many of the training techniques, e.g. sacking with the blanket, the stalled horses required more time to habituate. During the riding period, no differences were identified in training times.

Studies on free-roaming Camargue horses (Duncan, 1980), Przewalski horses (Hogan et al., 1988) and pasture-reared Quarter Horse foals (Heleski et al., 1999) showed that the horses spent a high percentage of their time grazing. For stalled horses, their restricted environment hinders the opportunity for them to walk around and graze. Without the opportunity to forage, a lesser amount of time is required for the stalled horses to eat. Hogan et al. (1988) suggested that the lack of opportunity to graze results in the horses having extra time and unspent energy. Energy expenditure was not measured in this study. However, the stalled horses did perform many of the negative, undesirable behavioral responses predicted by Hogan et al. (1988). An increase in activity levels, displayed by the increased frequency of behaviors such as bucking and jumping, looking towards the wall, circling, and head and neck extension up, down and straight may be a result of unspent energy due to stalling.

Habituation, in this study, was the primary learning concept used during the groundwork period. The horses had to acclimatize to repetitive exposure of various stimuli such as the blanket, saddle and weight on their back. The daily challenges from the pasture environment may have helped the horses acclimatize easier to the training environment. The opportunity to explore objects in the environment and play with other horses may have an influence on a horse's response to training. Enriched environments provide challenges to animals, and these experiences may help in adapting to situations, such as locating food or shelter (Sheperdson et al., 1993).

Play contributes towards the behavioral, social and physiological development for all horses (Waring, 1983). It functions as a way of practicing and perfecting adult behavior skills that may be necessary in life for a wide range of actions (Fraser, 1992). Fagan (1981) suggested playing among animals helps develop cognitive skills necessary for behavioral adaptability, flexibility, inventiveness or versatility.

4.2. Horse behaviors during the riding portion of training

Behaviors observed during the riding period, and even the groundwork period, were typical for young horses that have never been trained. Head and neck extension up and straight were observed more frequently during the riding period with the stalled horses. On day 0, the trainers used the halter with a lead rope to direct the horses while riding. By day 7, the trainers began using a bridle and snaffle bit. The jointed snaffle bit applies direct pressure backwards or sideways on the mouth of the horse (C.H.A., 1996). When the trainer applied pressure to the reins for the horses to move in a direction, the horses would respond by following the cue or trying to evade the bit by moving their heads either up, down and straight. One possible interpretation is that stalled horses' excessive head movements indicate they were having difficulty in associating the trainers' commands and the movement of the snaffle bit.

In this study, the horses bucked and jumped primarily while being chased with or without a saddle on their back and occasionally during the riding period. The stalled horses bucked and jumped more often than the pastured horses on days 7, 21 and 28. A horse may buck and jump in the presence of pain, if the horse is confused, startled or is ‘‘feeling’’ playful (Fraser, 1992).

The change in the relationship between the stalled horses and the humans may have been a factor resulting in the observed unwanted behaviors of these horses during riding. At first, for the stalled horses the relationship with humans was a positive one, since humans were a source of food, water and an opportunity for exercise. Once training began, horses may have had difficulty adapting to this new, less positive interaction with humans.

A horse's tail setting will commonly accompany facial, neck and leg expressions (Waring, 1983). In this study, the pastured horses tended to carry a normal tail. In most breeds of horses, a relaxed horse carries its tail down while an elevated tail can indicate excitement, play, aggression, alarm or when a horse is not comfortable with a handler (Waring, 1983). However, in the Arabian breed of horses a slightly elevated tail is desirable and considered a normal, relaxed tail setting.

4.3. Cortisol

Overall, cortisol concentrations were high when compared to other studies. Mean cortisol values for horses housed in stalls and on pasture with no training have been reported at 163 ± 14 nmol/l, while trained horses exhibited cortisol levels ranging between 90 and 190 nmol/l (Irvine and Alexander, 1994). Plasma cortisol concentrations in this study ranged from 180 to 750 nmol/l. The cortisol levels in the present study were higher when compared to horses undergoing an endurance race who demonstrated mean cortisol levels of 465 nmol/l after the race was completed (Jensen-Waern et al., 1999).

This study revealed an increase in cortisol concentrations due to exercise with a significant decrease by 75 min post-training. The increase after exercise is comparable to many studies conducted with horses when cortisol rose after exercise (Church et al., 1987). The 15 min post-training cortisol concentrations were still elevated. However, by 75 min post-training the levels had decreased. This is comparable to other cortisol studies where cortisol levels will decrease by 30 min post exercise (Rose et al., 1983).

Contrary to our hypothesis, there were no differences between housing treatments in cortisol concentrations over training days. Studies have shown that cortisol may increase (Hennessy and Weinberg, 1990; Boulton et al., 1997) or not change (Freeman, 1985) in response to a stressor. Dallman et al. (1987) suggested that the threshold for adrenocortical system responses might be considerably higher than for behavioral systems. Linden et al. (1990) demonstrated a strong correlation between the post-ACTH and post-exercise cortisol concentration increase, suggesting that each individual has a specific stress-induced response independent of the type of stress. Since days 0 and 7 of the study focused on habituation training with limited riding for physical exercise, it is possible that with a more strenuous or longer training regimen a different treatment adrenocortical response may have been observed.

This study found an increase followed by a decrease in basal cortisol levels according to training days. On both days 0 and 21 basal cortisol concentrations were lower for each sample collection time compared to the training days 7 and 28. The difference between basal cortisol levels over training days was unexpected and warrants further research.

4.4. Heart rate

No effect of housing on heart rate values was observed. Considering the potentially different levels of physical fitness resulting from the difference in exercise opportunities between treatment groups, these results were unexpected.

Marsland (1968) suggested an untrained horse with poor physical fitness during submaximal exercise would exhibit higher heart rates at rest and during exercise. In this study, mean resting (basal) levels averaged 58.3 beats/min for pasture and 48.5 beats per minutes for the stalled treatment groups. These heart rates were similar to the range reported for comparably aged horses of 44–65 beats/min (Evans et al., 1994; Evans et al., 1990). Anticipation has been shown to affect resting heart rates in horses moved from their home stall to preparation shed and track (Hall et al., 1976). This scenario is similar for the pastured group who incidentally exhibited higher mean resting heart rates. The pastured group was removed from the pasture and led into a stall one hour prior to training. First the horses were equipped with the heart rate monitors, then before or after entering the training arena, the first blood samples were drawn. With the pasture group, the increased activity that occurred prior to the start of training may have elicited an anticipatory effect, reflected through the increase in basal heart rates.

The dual innervation between the parasympathetic and sympathetic mechanisms causes variability in heart rate and the variability may serve as an important mechanism for adaptability, during a stress response (Porges, 1992). In this study, measures of heart rate variability may have provided important information. Due to technical difficulties these data were not analyzed.

5. Conclusion

Housing conditions are an important aspect that should be considered when training young horses for the first time. Research over the last decade has proven that barren housing conditions can affect an animal's behavior and learning abilities. The physiological data in this study did not identify differences between housing, although the data did reveal that initial training is a stressful event. The present study did, however, provide the first in-depth assessment of the effects of housing conditions on the responses of horses to training.

Land for pasture housing may not be accessible to or feasible for every horse owner. Nonetheless, horse owners should try to provide horses with a more enriched environment, if not through pasture housing, perhaps by increasing the amount of time a horse spends in a paddock. Future studies examining partial pasture turnout versus stalled housing conditions on training behaviors and physiological measures may demonstrate further that increased opportunities for social interaction or the chance to release excess energy can be beneficial in increasing the trainability of the horses. In addition, examining young horses in the partial pasture condition, either isolated or with other horses, may help to determine which factor, exercise or social interaction, is more critical for improving trainability of the young horse.

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References

Baldock, N.M., Sibly, R.M., 1990. Effects of handling and transportation on the heart rate and behaviour of sheep. Appl. Anim. Behav. Sci. 28, 15–39.

Boulton, M.I., Wickens, A., Brown, D., Goode, J.A., Gilbert, C.L., 1997. Prostaglandin F2 α-induced nest-building in pseudopregnant pigs. I. Effects of environment on behavior and cortisol secretion. Physiol. Behav. 62, 1071–1078.

Certified Horsemanship Association (C.H.A.), 1996. Composite Horsemanship Manual. C.H.A., Texas, pp. 3–14.

Church, D.B., Evans, D.L., Lewins, D.R., Rose, R.J., 1987. The effect of exercise on plasma adrenocorticotropin, cortisol and insulin in the horse and adaptations with training. In: Gillespie, J.R., Robinson, N.E. (Eds.), Equine Exercise Physiology 2. Edward Bros. Inc., USA, pp. 506–515.

Dallman, M.F., Akana, S.F., Casio, C.S., Darlington, D.N., Jacobson, L., Levin, N., 1987. Regulation of ACTH secretion: variations on a theme of B. Recent Prog. Horm. Res. 43, 113–173.

Duncan, P., 1980. Time budgets of Camargue horses. II. Time budgets of adult horses and weaned sub-adults. Behaviour 72, 26–49.

Evans, J.W., Borton, A., Hintz, H., Van Vleck, D.L., 1990. The Horse, 2nd Edition. Freeman, New York, pp. 775–779.

Evans, D.L., Hodgson, D.R., Rose, R.J., 1994. The Athletic Horse: Principle of Equine Sports Medicine. Saunder, Philadelphia, pp. 132–136.

Fagan, R.M., 1981. Animal Play Behavior. Oxford University Press, Oxford, p. 648.

Fraser, A.F., 1992. The Behavior of the Horse. Redwood Press Ltd., Melksham, pp. 159–257.

Freeman, B.M., 1985. Stress and the domestic fowl: physiological fact or fantasy? World's Poult. Sci. J. 41, 45–51.

Hall, M.C., Steel, J.D., Stewart, G.A., 1976. Cardiac monitoring during exercise tests in the horse. 2. Heart rate responses to exercise. Aust. Vet. J. 52, 1–5.

Heleski, C.R., Shelle, A.C., Nielsen, B.D., Zanella, A.J., 1999. Influence of housing on behavior in weanling horses. In: Proceedings of the 16th Equine Nutrition Physiology Symposium, Raleigh, NC, pp. 249–250.

Hennessy, M.M.B., Weinberg, J., 1990. Adrenocortical activity during conditions of brief social separation in preweaning rats. Behav. Neural. Biol. 54, 42–55.

Hogan, E.S., Houpt, K.A., Sweeney, K., 1988. The effect of enclosure size on social interactions and daily activity patterns of the captive Asiatic Wild Horse (*Equus przewalskii*). Appl. Anim. Behav. Sci. 21, 147–168.

Irvine, C.H.G., Alexander, S.L., 1994. Factors affecting the circadian rhythm in plasma cortisol concentrations in the horse. Domest. Anim. Endocrinol. 11, 227–238.

Jensen-Waern, M., Lindberg, A., Johannisson, A., Grondahl, G., Lindgren, J.A., Essen-Gustavsson, B., 1999. The effects of endurance ride on metabolism and neutrophil function. Equine Vet. J. Suppl. 30, 605–609.

Kiley-Worthington, M., 1990. The behavior of horses in relation to management and training-towards ethologically sound environments. Equine Vet. Sci. 10, 62–71.

Kirkpatrick, J.F., Francis, M.H., 1994. Into the wind. Wild Horses of North America. North Wood Press, Inc., Minocqua, WI, pp. 65–87.

Linden, A., Art, T., Amory, H., Desmecht, D., Lekeux, P., 1990. Comparison of the adrenocortical response to both pharmacological and physiological stresses in sport horses. J. Vet. Med. A. 37, 601–604.

Marsland, W.P., 1968. Heart rate response to submaximal exercise in the Standardbred horse. J. Appl. Physiol. 24, 98–101.

Mendl, M., Paul, E.S., 1991. Litter composition affects parental care, offspring growth, and the development of aggressive behaviour in wild house mice. Behaviour 116, 90–108.

National Research Council, 1989. Nutrient Requirements of Horses, 5th Edition. National Academy Press, Washington, DC, p. 43.

Porges, S.W., 1992. Vagal tone: a physiologic marker of stress vulnerability. Pediatrics 90, 498–504.

Rose, R.J., Hodgson, D.R., Sampson, D., Chan, W., 1983. Changes in plasma biochemistry in horses competing in a 160-km endurance ride. Aust. Vet. J. 60, 101–105.

Sheperdson, D.J., Carlstead, K., Mellen, J.D., Seidensticker, J., 1993. The influence of food presentation on the behavior of small cats in confined environments. Zool. Biol. 12, 203–216.

Waring, G.H., 1983. Horse Behavior. The Behavioral Traits and Adaptations of Domestic and Wild Horses, Including Ponies. Noyes Publications, Park Ridge, NJ, pp. 218–234.