Can we determine the presence of musculoskeletal pain by ridden horse behaviour? Use of the Ridden Horse Pain Ethogram

Sue Dyson, Independent consultant

sue.dyson@aol.com

Introduction

There are many horses that appear sound in hand but have underlying pain-related musculoskeletal problems when ridden. However, horses show a variety of gait modifications in an attempt to reduce pain and minimise lameness, including reducing range of motion of the thoracolumbosacral region[1], taking shorter steps, alteration of limb flight and increasing body lean[2]. It is apparent that owners, riders and trainers have a poor ability to recognise signs of lameness. In a study of 506 sports horses in normal work and presumed to be sound, 47% were overtly lame, or had other pain-related gait abnormalities (e.g., stiff, stilted canter)[3]. In an unrelated study of 201 riding horses in full work and functioning normally, 53% had gait asymmetry when evaluated trotting in hand, determined using inertial measurement units[4]. Analysis of 57 dressage and showjumping horses in normal work revealed that 65% exhibited lameness either in hand on the lunge or ridden; 47% showed lameness ridden and 7% were only lame ridden[5]. Riders and trainers often label performance problems experienced during ridden exercise as training-related, rider-related, or behavioural, or 'that is just how the horse has always gone'[6,7]. Consequently pain-related problems often get insidiously, but progressively worse. Inability to perform satisfactorily may result in a decline in value of the horse and the standards of care[6]. Improved pain recognition will enhance equine welfare.

Many veterinarians have had little training in pain recognition and limited education in identification of low-grade lameness, especially in ridden horses, and therefore struggle to recognise musculoskeletal pain as a cause of poor performance. Owners are frustrated when they think that their horse has an underlying pain-related problem, but are informed by their veterinarian that there is no detectable lameness and the problem must be 'behavioural'. It would therefore be useful to have additional tools for owners, trainers, veterinarians and other paraprofessionals to recognise signs of musculoskeletal pain.

Behavioural changes related to experimentally-induced orthopaedic pain in horses have been described[8,9], but the features described, such as pawing the ground, are generally not applicable to ridden horses. The most recent advance in the recognition of subtle behavioural changes associated with pain is the investigation of facial expressions[10]. The spectrum of facial expressions exhibited by normal horses under non-ridden circumstances has been described in detail[11]. An 'equine pain face' was developed to describe facial features of horses with induced limb pain at rest[12]. A Horse Grimace Scale, consisting of six features ('the ears held stiffly backwards; orbital tightening [the eyelids are partially or completely closed]; tension above the eye; the mouth strained with a pronounced chin; the nostrils strained with flattening of their profile; and prominent strained chewing muscles') was developed to categorise the facial expressions of horses undergoing routine castration, with or without perioperative analgesia[13]. However, it has been suggested that posture changes and overall body tension in resting horses may confound results and that further research is required to test for reliability of 'pain grimace' measures[14]. The Equine Utrecht University Scale for Facial Assessment of Pain (EQUUS-FAP) was developed to assess facial pain expressions in horses with or without abdominal pain and used a 3-point system from 'normal = 0' to 'maximal visible pain' for nine facial parameters, to derive an overall pain scale[15]. This system showed good reliability among four veterinary students and two veterinarians when looking at 10-minute video recordings of stabled horses.

An initial outline of a scheme to assess some aspects of facial expression in ridden horses has been described[16], however a detailed description of the results was not documented. Head movement, ear position, teeth grinding and lip movements were described in a study comparing two groups of young horses (3.5 years of age) when first lunged under a saddle and first ridden at a trot following either a ‘conventional training approach’ or a ‘sympathetic training approach’[17].

An ethogram is a catalogue of behaviours with specific definitions. An ethogram purpose-designed to describe facial expressions in ridden horses (FEReq) was developed[18], and it was shown that it could be applied by observers from variable professional backgrounds with satisfactory agreement. It was also demonstrated that a trained assessor could differentiate between lame and non-lame horses based upon application of the FEReq to photographs of the horses’ heads[19,20].

It has frequently been recognised by the review of patient history that the presence of musculoskeletal pain in horses has long pre-dated its recognition, because owners and trainers have failed to recognise the significance of behavioural changes during ridden exercise[21-30]. In horses some behaviours such as bucking[29], head tossing[31] and rearing[32] during ridden exercise have been associated with musculoskeletal pain, and classical headshaking has been associated with trigeminal neuralgia[33-36]. However, the association between other behaviours and pain, such as unwillingness to go forwards or being ‘above the bit’, has been poorly documented.

It was postulated that these relatively easily observed signs might be used to develop a Ridden Horse Pain Ethogram that could improve the ability of minimally trained observers to differentiate horses with musculoskeletal pain from those with other behavioural, training or rider problems.

Development of the Ridden Horse Pain Ethogram

The purpose of the initial study was to develop a Ridden Horse Ethogram and to determine whether it could be applied repeatedly by one trained observer (Repeatability Study, 9 horses) and if, by application of a related pain behaviour score, lame horses (n=24) and non-lame horses (n=13) could be differentiated[37]. It was hypothesised that there would be some overlap in behaviour scores among non-lame and lame horses; and that overall, non-lame horses would have a lower behaviour score than lame horses. The ethogram was developed with 117 behaviours and horses were graded twice in random order by a trained observer using video footage. Overall, there was good correlation between the two assessments ($p<0.001$; $R^2=0.91$). Behaviours that were not consistent across the two assessments were omitted, reducing the ethogram to 70 behaviours. The modified ethogram was applied to video recordings of the non-lame horses and lame horses (Ethogram Evaluation). By the amalgamation of similar behaviours and by omission of those which showed unreliable results in relation to lameness the Ridden Horse Pain Ethogram was ultimately developed. This comprised 24 behaviours, the majority of which were at least 10 times more likely to be seen in lame horses versus non-lame horses (Table 1).

The maximum individual occurrence behaviour score for lame horses was 14/24, with a median score of 9 and a mean score of 9 (standard deviation [SD] ±2), compared with a maximum score of 6 for non-lame horses, with a median and a mean score of 2 (SD±1.4). The following behaviours occurred significantly more frequently in lame than non-lame horses ($p<0.05$, Chi-square): one or both ears behind vertical for ≥ 5 s, mouth opening with separation of the teeth for ≥ 10 s, tongue out, change in eye posture and expression, front of head ≥30° in front of the vertical for ≥ 10 s (‘above the bit’), head tossing, tilting the head, unwillingness to go, crookedness, hurrying, changing gait spontaneously, poor quality canter, resisting or not following the direction of the rider’s cues, and stumbling and toe dragging. It was concluded that the presence of eight or more of the 24 behaviours was likely to reflect musculoskeletal pain.

Application of the Ridden Horse Pain Ethogram (RHpE) to horses with musculoskeletal pain and comparison before and after diagnostic anaesthesia

To provide further evidence that the behaviours were a reflection of musculoskeletal pain, video recordings of 10 lame horses were reviewed blindly in random order by a trained assessor before and after diagnostic anaesthesia resolved the baseline lameness and improved any gait abnormalities seen in canter[38]. The mean and median scores before diagnostic anaesthesia were 12.1 and 12 out of 24, respectively (range 6-14). After lameness resolution the mean and median scores reduced to 5.9 and 5 respectively (range 3-10). The marked reduction in RHpE scores following resolution of lameness verified a causal relationship between musculoskeletal pain and the behaviours.

An additional study demonstrated that non-trained assessors from different professional backgrounds could differentiate between lame horses before and after diagnostic anaesthesia had abolished low-grade lameness (most frequent lameness grade 2/8) by application of the Ridden Horse Pain Ethogram[39]. Anonymised video recordings of 21 lame horses, ridden by professional riders in trot and canter before and after diagnostic anaesthesia had abolished lameness, were reviewed in a random order by a trained assessor and 10 untrained assessors. For each horse the duration of the recordings before and after diagnostic anaesthesia was time matched. The RHpE scores of the 21 lame horses prior to diagnostic anaesthesia ranged from 3.6 to 11.6/24 (median 9; mean 9.1). After lameness and overall performance had been substantially improved using diagnostic anaesthesia, the number of behaviours was significantly reduced ($p<0.0001$) ranging from 1.6 to 8.5/24 (median 4.5; mean 4.2).

Application of the Ridden Horse Pain Ethogram in real-time

Ten equine veterinarians (the ‘test observers’) (after preliminary training) and an experienced assessor applied the RHpE to 20 horse-rider combinations performing a purpose-designed dressage test (8.5 minutes)[40]. The horses were a convenience sample, in regular work, and capable of working ‘on the bit’. Video-recordings of the test were analysed retrospectively by the experienced assessor. Lameness or abnormalities of canter, saddle-fit, the presence of epaxial muscle tension/pain and rider-skill-level were determined by independent experts. Sixteen horses were lame; 11 had an ill-fitting saddle; 14 had epaxial muscle tension/pain. The experienced assessor determined total RHpE scores of 3-6/24 for the non-lame horses; two lame horses scored 3 and 6; 14 lame horses scored 8-16. There was no significant difference in real-time scores and video-based scores for the experienced assessor. There was good agreement between the experienced assessor’s scores and the mean test observer scores. There was excellent consistency in overall agreement among raters (Intraclass-correlation 0.97, $p<0.001$). There was a significant difference between ethogram scores according to lameness-status for real-time ($p=0.017$) and video ($p=0.013$) observations by the experienced assessor and for the test observers’ mean ($p=0.03$). There was no significant effect of muscle pain, saddle-fit or rider-skill on behaviour. It was concluded that the RHpE was applied consistently by veterinarians with differentiation between non-lame and most lame horses. After appropriate training in its application, the ethogram may provide a useful tool for determining the presence of musculoskeletal pain in horses performing poorly.

Application of the Ridden Horse Pain Ethogram and its association with performance

The potential power of the RHpE was demonstrated by its application to horses warming up for dressage at five star three-day-events[41]. Horses were each assessed for a minimum of 10 minutes during trot and canter. Horses were classified subjectively as non-lame, lame or showing a stiff, stilted gait. The RHpE was applied by a trained assessor. Cross-country performance was obtained from the competition website; horses were classified as completing, eliminated or retired. Horses with a Ridden Horse Pain Ethogram score of ≥7/24 compared with horses with a score <7 had higher dressage penalties, were more than twice as likely to be eliminated or retire during cross-country; those horses which finished had significantly lower finish places. Horses can pass a veterinary inspection but show gait abnormalities when ridden, highlighted by behavioural changes. Gait abnormalities may compromise cross-country performance in some horses, although a causal relationship between failure to complete and gait abnormalities cannot be proven.

Associations between RHpE scores and performance have also been demonstrated at lower level one-day events (British Eventing 90, 100 and Novice)[42] and at elite and sub-elite Grand Prix dressage[43,44].

The influence of rider size on ridden horse behaviour

In a prospective, cross-over, randomised trial six non-lame horses in regular work, 500-600 kg bodyweight, were ridden by four riders of similar ability, but different bodyweights (rider:horse bodyweight 10-12% [L=Light], >12≤15% [M=Moderate], >15<18% [H=Heavy], >20% [VH=Very Heavy]), performing a standardised 30-minute dressage test [45]. Horses were evaluated throughout the test for the presence of lameness and the RHpE was applied in real-time. Tests were abandoned for ≥grade 3/8 lameness or ≥10 behavioural markers (assessed in real-time). The RHpE was also applied retrospectively to video recordings of predefined parts of the test in trot and canter by an experienced assessor.

All 13 H and VH rider tests were abandoned (temporary lameness, n=12; behaviour, n=1 [10/24 behaviours in canter), as was one of 12 M rider tests (temporary lameness). For the retrospective video analysis there were significant differences among riders in the total RHpE score for trot (Anova, Bonferroni: M vs H, P<0.01; L and M vs VH, P<0.001; H vs VH, P<0.05). The total RHpE scores correlated positively with rider weight (Spearman: R=0.4, P<0.01), although in only one of 37 tests was the total RHpE score ≥ 8. The number of behaviours reflecting head position and facial expression were significantly higher with the heavier riders (Anova, Bonferroni: P<0.001-0.05), whereas body markers (head and tail movement) and gait markers (behaviour, not kinematics) showed non-significant changes. Statistical comparisons for canter could not be performed because of early abandonment of tests for the H and VH riders.

It was concluded that rider size (height and weight) may influence ridden horse behaviour, which may reflect discomfort.

Discussion

The observation of eight or more of the 24 behaviours of the RHpE is likely to reflect the presence of musculoskeletal pain, although some lame horses exhibit less than eight behaviours. It is important to observe horses from all perspectives (from in front, behind and the side), performing at least trot and canter and transitions between gaits both going around the periphery of an arena and performing 10 metre diameter circles in rising trot to ascertain comprehensive scoring. Some horses show more signs consistent with pain in canter compared with trot or vice versa. However, pain may only be manifest in some horses doing more specialised and physically demanding movements (e.g., shoulder-in, collected trot half-pass, canter flying changes), so inclusion of these in the assessment for some horses is recommended. Observation of a horse working for five to ten minutes should be adequate.

There is no correlation between lameness severity when ridden and the RHpE score. It should be borne in mind that if lameness is present in more than one limb it may not be graded accurately. There is also marked diversity of the occurrence of each of the 24 behaviours which is not necessarily related to lameness grade, but to physical musculoskeletal discomfort and perception of pain by the individual horse[37-40]. However, a RHpE score of eight or more indicates pain, even if overt lameness is not observed. This is important when assessing a horse prior to purchase, evaluating a horse with a history of poor performance, and when performing routine assessments of sports horses to determine if performance could be enhanced. Early recognition of musculoskeletal pain, and accurate identification of the source(s) of pain, may enable successful treatment and thus improved performance, and minimise the risk of the development of secondary problems.

Training improved accuracy of interpretation of the FEReq[37] and the RHpE[40] and is strongly recommended. On-line training is available[46]. The definitions for each behaviour need to be recognised, understood and correctly applied. A number of factors need to be assessed before application of the RHpE. In some horses the sclera is visible at rest in one or both eyes, so this observation should not be included in the RHpE score. If the bit is too wide, it may erroneously be concluded that it has been pulled through to one side. If the footing is very deep this may induce hindlimb toe drag, which may not be observed on a better surface. The presence of oral lesions which may influence behaviour should be recognised.

Some of the features of the RHpE could also be influenced by the type of bit and its use, the rider's skill and balance and use of their hands. However, we have demonstrated that the RHpE scores of lame and non-lame horses ridden by riders of differing ability are similar, although work quality may differ[47]. The mouth repeatedly opening with separation of the teeth and the tongue protruding were both significantly associated with lameness[38]. It has been suggested that such evasions could also be a reaction to the presence of a bit[48-51], or an ill-fitting noseband[52-55]. However, such evasive behaviour may prompt owners to introduce nosebands such as a crank noseband with a flash or to tighten nosebands rostral to the bit.

Although saddle fit did not significantly influence behaviour scores in one study[40], an ill-fitting saddle does have the potential to induce abnormal behaviours, that disappear if a better fitting saddle is used.

There are a number of additional features which have not been assessed objectively, but which are of potential clinical relevance during ridden exercise: teeth grinding, abnormal breathing noises, grunting, and sweating disproportionate to the level and amount of work, fitness and environmental temperature. The frequency of defaecation and consistency of faeces should be observed. There are features that may be felt by a rider: episodic shooting forwards, absence of rein tension (not taking a contact), symmetrically increasing rein tension (hanging on the reins), asymmetrical rein tension (hanging on one rein more than the other), reduced range of motion of thoracolumbosacral region ('back stiffness'), tension, lack of hindlimb impulsion, and being on the forehand. There are also features of gait that are difficult to reliably measure without high-speed video, such as alterations in canter (e.g., temporal and spatial separation of the hindlimbs during the stance phase). Assessment of blink rate was not performed, but may be useful for future studies. Increased blink rate has been linked positively to the amount of dopamine in the basal ganglia of the brain[56] and dopamine levels may increase as a result of pain[57]. The posture of the horse after exercise should also be observed.

Definitive differentiation between pain, or discomfort induced by tack and other innate behavioural reasons cannot be made on the basis of these studies. When a horse is learning a new movement, it may misunderstand the rider's cues or find it physically difficult due to the unaccustomed use of specific muscle groups, which may result in delayed onset muscular stiffness[58,59]. Conflict behaviour[60] or resistant behaviour may be displayed, but persistence of such behaviours would not be expected unless there was an underlying pain-related problem. Recognition of changes in behaviour facilitates recognition of improvement in performance and willingness to work following improvement or resolution of pain causing lameness using diagnostic anaesthesia. Persistence of a RHpE score of eight or more is likely to indicate residual musculoskeletal pain, requiring further investigation.

The RHpE was developed in sports horses used in the Olympic disciplines in which the horse is expected to work with the front of the head in a vertical position, 'on the bit', when performing schooling-type work. However, other than head position, the ethogram is readily transferable for other types of work (e.g., jumping), when working individually, although close proximity of other horses may influence behaviour. Minor adaptations may be required for application of the RHpE to Icelandic horses[61].

Conclusions

It is concluded that the demonstration of eight or more of the 24 behaviours of the RHpE is highly likely to reflect the presence of musculoskeletal pain in sports horses, although some lame horses score less than eight. It is considered important that those interacting in any way with or responsible for horses are educated about the signs that may reflect pain when horses are ridden (e.g., ears back, mouth opening, tongue out, change in eye posture and expression, going above the bit, head tossing, tilting the head, unwillingness to go, crookedness, hurrying, changing gait spontaneously, poor quality canter, resisting, and stumbling and toe dragging). If changes in body postures and resistance to following commands could be used to alert riders of potential pain, then the welfare of horses could be significantly improved. Horses would not fall victim to harder training practices that could further aggravate musculoskeletal pain, or to a punishment-based training regimen to address the animal's unwillingness to follow commands of the rider.

Table 1 The 24 behaviour Ridden Horse Ethogram, adapted from Dyson et al. [37]

1. Repeated changes of head position (up/down), not in rhythm with the trot
2. Head tilted repeatedly
3. Head in front of vertical (>30º) for ≥10s
4. Head behind vertical for (>10º) ≥10s
5. Head position changes from side to side, repeatedly
6. Ears rotated back behind vertical or flat (both or one only) ≥5s
7. Eye lids closed or half closed for 2-5 s
8. Sclera exposed repeatedly
9. Intense stare (glazed expression, 'zoned out') for ≥5s
10. Mouth opening ± shutting repeatedly with separation of teeth, for ≥10 s
11. Tongue exposed, protruding or hanging out, and/or moving in and out repeatedly
12. Bit pulled through the mouth on one side (left or right), repeatedly
13. Tail clamped tightly to middle or held to one side
14. Tail swishing large movements: repeatedly up and down/side to side/ circular; repeatedly during transitions
15. A rushed gait (frequency of trot steps > 40/15s); irregular rhythm in trot or canter; repeated changes of speed in trot or canter
16. Gait too slow (frequency of trot steps <35/15s); passage-like trot
17. Hindlimbs do not follow tracks of forelimbs but repeatedly deviated to left or right; on 3 (or 4) tracks in trot or canter
18. Canter repeated leg changes in front and / or behind: repeated strike off wrong leg; disunited
19. Spontaneous changes of gait (e.g., breaks from canter to trot or trot to canter) > once
20. Stumbles or trips more than once; repeated bilateral hindlimb toe drag
21. Sudden change of direction, against rider's directions/ cues; spooking
22. Reluctance to move forwards (has to be kicked ± verbal encouragement), stops spontaneously
23. Rearing (both forelimbs off the ground)
24. Bucking or kicking backwards (one or both hindlimbs)

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