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Review

Objective pain assessment in horses (2014–2018)

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ABSTRACT

In recent decades, much effort has been invested in scientific studies of objective and reliable assessment of pain in horses. Various types of pain assessment tools have been described and (partly) validated for different types of pain in horses. Currently, composite pain scales and facial expression-based pain scales seem to be the most promising tools for pain assessment in horses and numerous studies have recently been published on the use of these pain scales in horses. Therefore, this narrative review mainly focusses on these two types of pain scales and on the studies that have appeared describing these type of pain scales in horses. The extent to which these pain scales have been validated (sensitivity, specificity, inter-observer reliability etc.) and their potential use for clinical pain states is discussed. Possible future directions for new studies and their possible aid in assessing pain in hospitalised and ridden horses are presented. In this way, improved pain scoring could improve criteria used to evaluate the clinical efficacy of new analgesic drugs and techniques, potentially benefiting equine welfare.

Introduction

Pain is defined by the International Association for the Study of Pain (IASP) as an '*unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage*' (Merskey and Bogduk, 1994). For animal pain, the definition of Molony and Kent (1997) is often used: *'Pain is an aversive sensory and emotional experience, representing an awareness by the animal of damage or threat to the integrity of its tissues; it changes the animal's physiology and behaviour to reduce or avoid damage, to reduce the likelihood of recurrence and to promote recovery; unnecessary pain occurs when the integrity or duration of the experience is inappropriate for the damage sustained or when the physiological and behavioural responses to it are unsuccessful at alleviating it'*. Since pain contains, apart from the sensory discriminative components, an emotional component as well, it is a subjective experience that cannot be verbally communicated by animals. Therefore, the reference standard method to measure pain is not available for pain assessment in animals. In 1996, the American Pain Society (APS) introduced pain as the 'fifth vital sign'. This initiative emphasised that pain assessment is as important as the standard four vital signs (heart rate, respiratory rate, temperature and blood pressure) and that clinicians need to act when patients report pain. However, the subjectivity of pain perception and the difficulties with objective assessment in animals were also stressed by this initiative. Although scientific studies into objective pain assessment started to appear from then, in the first instance it was mainly work in companion animals and humans and the number of studies in objective pain assessment in horses was limited at that time (Taylor et al., 2002). Since the turn of the century, numerous studies on objective pain assessment in horses have appeared and the reviews by Gleerup and Lindegaard (2016) and De Grauw and van Loon (2016) provide a very in-depth and up-to-date overview of all the studies on equine pain scoring up till that time. Objective and reliable pain recognition is essential in treating horses in pain with a tailored analgesic protocol and allows to adjust the protocol to the needs of the patient (Daglish and Mama, 2016; Guedes, 2017).

The aim of this review is to discuss the more recent studies on equine pain assessment that have appeared between 2014 and 2018. The focus will be on composite pain scales and facial expression pain scales, since these have shown to provide the most accurate readings of animal pain. Furthermore, pain scales for pain assessment in ridden horses will be discussed, since these have recently appeared in literature. By reviewing this relatively limited number of new pain scales into more depth, we hope to provide more relevant details of these pain scales, in terms of study design, validity and limitations.

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Searches

Pubmed, Sciencedirect, WebofScience and Google were used with the following search terms: horse, equine, pain, scale, behaviour, behavior, facial expression, assessment.

Requirements for the ideal pain scale

Apart from practical applicability (in terms of ease of use, understandability of the criteria, time needed to perform pain assessment using a scale etc.), reliability and validity of the pain scale are very important. Validity is the ability of the pain score to measure what it is supposed to measure (De Vellis, 2003). Face validity means that the score is subjectively assessed by people that are experienced in that particular field of research (eminence based). Content validity determines whether the test items correspond with the phenomenon that is measured and is related to face validity. Criterion validity is the correlation with the reference standard, which is a difficult aspect to be determined in pain scoring in animals. Concrete validity indicates that the test outcome is related to the clinical outcome (e.g. survival after surgery) and construct validity determines whether the test really measures what it claims to be measuring. For construct validity, sensitivity and specificity (the true positive and true negative rate) can be calculated. Reproducibility can be assessed by means of inter- and intra-observer reliability. In most published clinical studies of pain scales, concrete and construct validity and reproducibility have been investigated. These different aspects of validity will be discussed in the relating sections of this review. Validation of a pain scale should ideally be at least a two-step process with two independent datasets. Firstly, a scale should be constructed by collecting the first dataset (e.g. patients and controls); this scale should be analysed for all test statistics as described above and the weighting values of each of the individual factors within this first dataset should be calculated to discriminate between patients and controls. Secondly, the entire data collection should be repeated in exactly the same way to obtain an independent second dataset (with new patients, new controls and new observers; Streiner and Norman, 1995). The test statistics should be analysed again for the second dataset and they should still fall within the required range. The weighting values of the first dataset can be applied to the second dataset to test the possible added value of these weighting factors. Finally, the response to an intervention (e.g. painful event in induced pain models such as LPS-induced synovitis, or analgesic treatment in naturally occurring or induced pain states) reflects the ability of the pain score system to measure changes in degree of pain over time (Hielm-Björkman et al., 2009).

Singular and composite pain scales

Various pain scales for measuring different types of pain in horses have been described by De Grauw and van Loon (2016) and by Gleerup and Lindegaard (2016). One of these pain scales was the Equine Acute Abdominal Pain Scale (EAAPS) by Sutton et al. (2013a and b), a simple ascending clinical index, that was designed to measure acute colic pain in horses. In a follow-up article by Sutton and Bar (2016), this pain scale, that was developed using formal clinimetric procedures (containing item generation, item selection, item weighting and testing reliability and validity), was presented in a refined and revalidated version of the EAAPS-1 version of the pain scale (Appendix: Supplementary material 1). The revalidated EAAPS showed very good reliability and validity and is practically applicable in horses with acute colic, either for direct observations or for observations from video footage. (Table 1). Scoring of the horses in this study was performed from video footage (median length of video clips, 27 s; interquartile range, 19–46 s). Pain scoring using the revalidated EAAPs score took < 2 min for the observers.

Composite pain scales include multiple variables (very often behavioural, physiological or both) that are scored using well-defined classes by means of Simple Descriptive Scales (SDS), which are then combined to provide an overall composite pain score. Van Loon and van Dierendonck (2015) introduced the EQUUS-COMPASS (Equine Utrecht University Scale for Composite Pain Assessment), that was constructed for measurement of acute colic in horses (25 horses with acute colic and 25 control horses; Appendix: Supplementary material 2) and was performed by live observations. In a follow-up study (van Dierendonck and van Loon, 2016), this scale was validated with a new cohort of horses with acute colic ($n = 23$) and healthy control horses ($n = 23$), as well as new assessors. The EQUUS-COMPASS is based on the CPS by

Table 1
Comparison of different composite pain scales.

Name of scale	Authors	Type of pain	Number of animals	Inter-observer reliability	Validity
CPS	Bussières et al. (2008) and Van Loon et al. (2014)	Acute orthopedic Postoperative pain after emergency gastrointestinal surgery	18 48	*K*-coefficient 0.8–1.0 *K*-coefficient 0.84	Sens = good Spec = good Significant difference between survivors and non-survivors
EAAPS	Sutton et al. (2013a and b) and Sutton and Bar (2016)	Acute colic	28 horses with acute colic, six control horses	ICC = 0.88	Face val. = 71% Pred. val. = 0.75 for mortality Pred. val. = 0.76 for treatment modality
EQUUS-COMPASS	Van Loon and van Dierendonck (2015) and van Dierendonck and van Loon (2016)	Acute colic	48 horses with acute colic, 48 control horses	ICC = 0.98	Sens1 = 87% Spec1 = 71% Sens2 = 100% Spec2 = 76%
UNESP-Botucatu	Taffarel et al. (2015)	Post castration or post-GA	12 equine patients, 12 control horses	*K*-coefficient for individual parameters	Spec for individual parameters
Composite pain scale	Gleerup and Lindegaard (2016)	Clinical pain	–	Not determined	Not determined

ICC, intra class correlation coefficient; Face val., face validity; Pred. val., predictive validity; Sens, sensitivity; Spec, specificity; Sens1, sensitivity for differentiation between horses with colic and healthy control horses; Spec1, specificity for differentiation between horses with colic and healthy control horses; Sens2, sensitivity for differentiation between conservative and surgical treatment of horses with colic; Spec2, specificity for differentiation between conservative and surgical treatment of horses with colic; GA, general anaesthesia.

Bussières et al. (2008) and showed good validity (sensitivity and specificity for discrimination between healthy control horses and horses with colic and between different types of colic) and good reproducibility (Table 1). Furthermore, it was also useful for follow-up of horses over time, which makes this scale applicable for horses with acute colic. Assessing pain with this pain scale takes 5 min to observe and assess clinical parameters. The CPS by Bussières et al. (2008) was also used to monitor postoperative pain after emergency gastrointestinal surgery in horses by Van Loon et al. (2014) and can therefore be used with validity for different types of pain, since it was originally designed to assess acute orthopaedic pain in the study by Bussières et al. (2008). Taffarel et al. (2015) described the UNESP-Botucatu multidimensional composite pain scale for assessing pain in horses after surgical castration (Appendix: Supplementary material 3). In this study, inter- and intra-observer reliability were assessed and construct validity was evaluated by means of differences in pain scores between different treatment groups (anaesthesia with or without pre-emptive analgesia, surgical castration under general anaesthesia with or without pre-emptive analgesia; Table 1) and the scale was subsequently refined (by excluding several variables and their criteria) based on these results. This study was performed with 12 young horses that underwent castration and 12 older control horses, including seven geldings and five mares. These authors empirically suggest that 5 min of live observation should be sufficient for observation of relevant pain-related behaviours. Gleerup and Lindegaard (2016) described the Equine Pain Scale (Appendix: Supplementary material 4), that was based on the findings of all reviewed studies they described, combined with their Equine Pain Face (Gleerup et al., 2015b). This composite pain scale has been described in several horses (with abdominal or orthopaedic pain) in their review, but has neither been validated for a specific type of pain; nor the repeatability, validity or reliability for the scale itself was analysed (Table 1). The authors state that pain evaluation can be executed in approximately 5 min with the Equine Pain Scale. As stated by the authors themselves, before this pain scale could be reliably used in clinically affected horses, it should undergo further validation and reliability studies.

Various case reports describing individual horses with painful conditions use custom made pain scales. Although these pain scales are mostly unvalidated, they can be very useful to follow an individual horse and its response to analgesic treatment. Minghella and Auckburally (2014) described a custom-made composite pain scale for a horse that underwent surgical mandibulectomy because of a mandibular tumor. This pain scale incorporated superficial and deep palpation variables. With this pain scale, the treatment effect of the analgesic protocol, that comprised local anaesthetic blocks administered by means of wound soaker catheters, could be followed. The pain scale that was constructed for the horse in this case report included interesting and relevant parameters (e.g. the parameters light and firm palpation of the painful/surgical area) that could possibly be of interest in other types of pain as well. However, limitations of this case report are that the scale was neither validated for inter-observer reliability, nor for discrimination between painful animals and control animals.

Facial expression-based pain scales

Charles Darwin already described the similarities between man and animals in expressing the same state of mind in his book 'The expression of the emotions in man and animals', indicating facial expressions as potential indicators of animal emotions (Darwin, 1872). Descovich et al. (2017) recently concluded that facial expressions can be useful in animals to complement existing tools in the assessment of welfare. Facial Action Coding Systems (FACS) have been originally developed in humans to provide a systematic methodology to investigate facial expressions (Ekman and Friesen, 1976). Individual action units are caused by contraction or relaxation of one or more facial muscles and FACS provide a systematic methodology of identifying and coding facial expressions on the basis of underlying facial musculature and muscle movement. These may be used to determine whether a combination of facial action units is involved in a certain type of emotion, such as the expression of pain (Wathan et al., 2015). Similar to the approach in humans, FACS have been developed for chimpanzees (Vick et al., 2007) and macaques (Parr et al., 2010) and the facial action coding system for horses (EquiFACS) has been described by Wathan et al. (2015). Facial expression-based pain scales have been designed for rodents (mouse grimace scale by Langford et al., 2010, rat grimace scale by Sotocinal et al., 2011), rabbits (Keating et al., 2012), sheep (McLennan et al., 2016), cattle (Gleerup et al., 2015a) and pigs (Viscardi et al., 2017). As in several other mammals, facial expressions in horses have been described to be valid indicators of emotional states (Hintze et al., 2016).

The first pain scale for horses that was based on facial expression parameters was the Horse Grimace Scale (HGS) by Dalla Costa et al. (2014; Appendix: Supplementary material 5). The HGS is a composite simple descriptive scale that comprises six facial parameters with well-defined categories of 0 to 2 (signs of pain not present, moderately or obviously present). In this original study, the pain scale was evaluated in horses that were undergoing surgical castration and the study also included a control group of horses that were undergoing anaesthesia without surgery (Fig. 1). The pain scale demonstrated good reliability, validity and correlated with a simultaneously assessed composite pain scale (Table 2). Pain scoring was based on photographs, selected from video footage, that were taken at different time points pre and post castration. In a follow-up study (Dalla Costa et al., 2016), 10 horses with acute laminitis were treated for this condition and were assessed with the both HGS and the Obel grade (widely used to determine the severity of laminitis). Horses with high HGS scores exhibited significantly higher Obel scores and were classified by veterinarians as being in a significantly more severe painful state. HGS scores ranged from 2 to 9 with a mean score of 5.8 at admission; these scores decreased during the treatment period to a mean of 3.5 (range, 1–6). In healthy pain free stallions before castration (Dalla Costa et al., 2014), HGS scores ranged from 0 to 3 and the pain scores increased to a maximum of 6 after castration. The influences of emotional states other than pain such as new environment, grooming and anticipation of food reward did not significantly change the HGS scores in horses that were not in pain (Dalla Costa et al., 2017), whereas fear increased the HGS scores slightly (without any statistical significance) in this pilot study. The Horse Grimace Scale has shown to be valid, quick (it takes < 2 min to perform) and reproducible for assessment of postoperative pain after castration, based on the findings of photos that have been taken from 40 horses (Dalla Costa et al., 2014). The scale has not been validated as such by means of a second independent dataset and has not been described in a study with video footage or direct dynamic observations, which limits the clinical applicability at this stage. The scale has been used for pain assessment in horses with laminitis with only a limited number of horses so far ($n = 10$; Dalla Costa et al., 2017).

Gleerup et al. (2015b) published their Equine Pain Face, that was also based on six facial action coding units and that was validated with two experimentally induced pain models (a tourniquet on the antebrachium and topical application of capsaicin) in six healthy pain free animals (Appendix: Supplementary material 6). They assessed the individual parameters of the Equine Pain Face (Fig. 2) by means of live observations, observations from video footage (for 10 min) and stills from these videos and compared the pain scores with heart rate and a composite pain score, modified from

Fig. 1. Horse Grimace Scale (Dalla Costa et al., 2014). The Horse Grimace Pain Scale with images and explanations for each of the six facial action units (FAUs). Each FAU is scored according to whether it is not present (score of 0), moderately present (score of 1) and obvious present (score of 2).

Lindegaard et al. (2010). Furthermore, they found no suppression of facial expressions in the presence of an observer, although the expressions were less pronounced whenever the horses tried to interact with the observer. Although the study set-up was good (using a cross-over design with each horse being compared to its own control scores and the scoring after application of two different pain types) the number of horses that was used in this study was limited ($n = 6$) and the fact that experimentally induced pain was observed limits the clinical applicability of this scale so far. Furthermore, no measure for reproducibility was included in this study.

Van Loon and van Dierendonck (2015) described a composite facial expression-based pain scale, the EQUUS-FAP (Equine Utrecht University Scale for Facial Assessment of Pain), that was designed to assess horses with acute colic pain (Appendix: Supplementary material 7). The EQUUS-FAP is a dynamic pain scale, that comprises facial action coding units and dynamic aspects such as teeth grinding, moaning, yawning, response to a sound etc. that are well-known head-related pain behavioural parameters from previous studies (Table 2). The pain score demonstrated good reliability and validity (Table 2) and the constructed scale was validated in a follow-up study using new animals (veterinary patients and control animals) and new observers (van Dierendonck and van Loon, 2016), showing good sensitivity and specificity. The EQUUS-FAP scale discriminated significantly between affected horses and control horses; between surgically treated and conservatively treated horses; and for monitoring over time. The same EQUUS-FAP was later also used to assess horses with acute and postoperative head-related pain (Van Loon and van Dierendonck, 2017). In these types of equine patients, the EQUUS-FAP also proved useful to significantly discriminate affected horses from control horses and to follow these horses over time. The EQUUS-FAP can be assessed from a 2-min live observation period and could therefore be effectively implemented in clinical practice.

Pain scales in ridden horses

Recently, facial expressions of ridden horses (FEReq) have been described by Mullard et al. (2017). These authors presented an ethogram that resembles the previously described facial characteristics and comprises features of the eyes, ears, mouth, nostrils, tongue and muzzle. Furthermore, head position relative to the vertical is taken into account (Appendix: Supplementary material 8; Fig. 3). Several assessors with different backgrounds (from

Table 2
Comparison of different facial expression-based pain scales.

Name of scale	Authors	Type of pain	n	Inter-observer reliability	Validity
Horse Grimace Scale (HGS)	Dalla Costa et al. (2014)	Post castration	40	ICC = 0.92	Accuracy = 73%
Horse Grimace Scale (HGS)	Dalla Costa et al. (2016)	Laminitis	10	ICC = 0.85	S.R. corr.coeff.1 = 0.65 S.R. corr.coeff.2 = 0.87
Equine pain face	Gleerup et al. (2015b)	Experimental	6 healthy animals	Not determined	$P < 0.05$ for comparison between pain scores in induced noxious stimuli and controls
EQUUS-FAP	Van Loon and van Dierendonck (2015) and van Dierendonck and van Loon (2016)	Acute colic	48 horses with acute colic, 48 control horses	ICC = 0.93	Sens1 = 77% Spec1 = 100% Sens2 = 67% Spec2 = 94%
EQUUS-FAP	Van Loon and van Dierendonck (2017)	Acute and postop head-related	23 affected horses, 23 control horses	ICC = 0.92	Sens = 80% Spec = 78%
FEReq	Mullard et al. (2017), Dyson et al. (2017) and Dyson et al. (2018a and b)	Orthopaedic pain in ridden horses	251 horses (lame and non-lame)[a] 37 horses (24 lame and 13 non-lame)	K-coefficient = 0.72	$P < 0.05$ for comparison between lame and sound horses and $P < 0.05$ for decrease in pain score after abolition of lameness

S.R. corr.coeff.1, Spearman Rho correlation coefficient between Horse Grimace Scale and Obel lameness score; S.R. corr.coeff.2, Spearman Rho correlation coefficient between Horse Grimace Scale and pain intensity, evaluated by veterinarians; Postop, postoperative; ICC, intra class correlation coefficient; Sens, sensitivity; Spec, specificity; Sens1, sensitivity for differentiation between horses with colic and healthy control horses; Spec1, specificity for differentiation between horses with colic and healthy control horses; Sens2, sensitivity for differentiation between conservative and surgical treatment of horses with colic; Spec2, specificity for differentiation between conservative and surgical treatment of horses with colic.

[a] Lame and non-lame horses (n = 150) in the study by Mullard et al. (2017), 101 horses (76 lame horses and 25 sound horses; seven lame horses before and after diagnostic analgesia) in the study by Dyson et al. (2017) and 37 horses (24 lame and 13 non-lame horses) in the study by Dyson et al. (2018a and b).

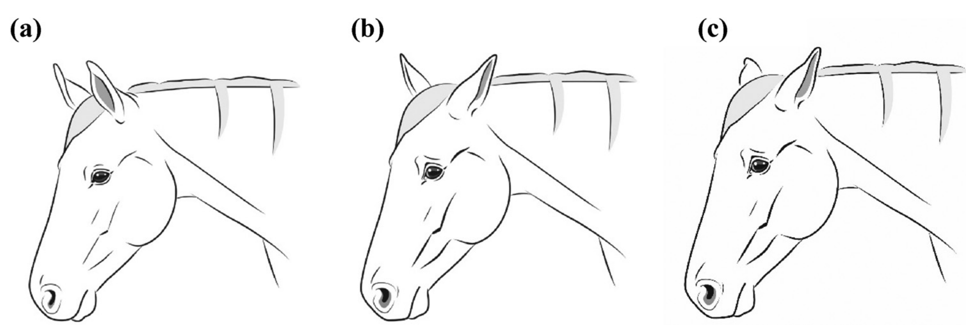

Fig. 2. Equine Pain Face (Gleerup et al., 2015b). (a) Facial expression of a pain free, relaxed and attentive horse. (b) Facial expression of a horse in pain, comprising all features of the pain face including asymmetrical ears. (c) Facial expression of a horse in pain, comprising all features of the pain face including low ears (drawings by Andrea Klintbjer).

amateur horse owners to veterinarians) were trained to use the ethogram and did not show differences in scoring (Table 2). In a follow-up study by Dyson et al. (2017), the FEReq has been assessed in lame ridden horses (n = 76), of which seven horses were assessed before and after diagnostic local anaesthetic blocks of the lame limbs, and 25 non-lame control horses were assessed. The FEReq was able to discriminate between lame and non-lame horses (Table 2). Position in relation to the bit, twisting of the head, asymmetrical position of the bit, ear position and eye features (including muscle tension caudal to the eye and an intense stare) were the best indicators of pain. The authors describe the limitations of their study regarding the fact that stills from videos were used instead of video recordings themselves. Other limitations in these studies were the differences between the groups of lame and sound horses: pictures from sound horses were taken during warm-up at international competition sites, while pictures from lame horses were taken during veterinary lameness examinations in a very heterogenous population of horses. In this way, the influence of circumstances and the rider-horse interaction were not randomly distributed over lame and control horses. Gleerup et al. (2018) suggested additional concerns regarding the methodology of these studies and the lack of results in the small pilot subset, allowing within-subject comparison before and after a positive local anaesthetic block. Apart from the limitations of these preliminary studies, they show the potential of changes in facial expression to detect subtle levels of lameness in ridden horses. Dyson et al. (2018a) responded to Gleerup et al. (2018) with a letter to the editor.

Recently, Dyson et al. (2018b) described the use of video footage for development of a pain scoring system in ridden horses in a follow-up article. In this study, 24 lame horses were compared with 13 sound horses. Furthermore, for nine horses (six lame horses), videos were scored twice by one observer which yielded good intra-observer repeatability (r^2 = 0.91, $P < 0.001$). The ethogram developed in this study consisted of an adapted form of the FEReq ethogram, together with further markers for general body language and behaviour while ridden, resulting in facial markers, body markers and gait markers. The group of sound control horses consisted of Warmblood horses, used for dressage and show jumping. The lame horse population was less homogenous, with various breeds that were used for general purposes. The most pronounced differences between lame and sound horses were

Fig. 3. Facial expressions in ridden horses (FEReq) by Mullard et al. (2017) and Dyson et al. (2017). Lateral images of test heads from horses 12 (A), 26 (B), and 30 (C). In (A), the right ear is erect with the pinna rotated outward. The left ear is forward. The right eye is open. The sclera cannot be seen. The mouth is slightly open but the tongue, teeth, and gums cannot be seen. Salivation is present. The lower muzzle is tense and angled, and the upper muzzle is extended and angled. The front of the horse's head is >30° behind the vertical. In (B), both ears are back. The left eye is open, almond-shaped, with tension of the levator anguli oculi medialis muscle. The sclera is visible. The left nostril is rounded and angular, with mediolateral widening and a wrinkle between the nostrils. The mouth is closed. Salivation is present. The upper muzzle is in line with the lower muzzle. The front of the horse's head is >30° in front of the vertical. In (C), the left ear is forward and the right ear is backward. The right eye is open, almond-shaped, with tension of the levator anguli oculi medialis muscle and an intense stare. The sclera is not visible. The mouth is open exposing the tongue and lower teeth but not the gum. There is no salivation. The lower muzzle is tense and angled and not in line with the upper muzzle. The front of the horse's head is <10° in front of the vertical. The right nostril is rounded and angular, with mediolateral widening.

found in body and gait related markers. The results of these studies do not justify the use of this pain scale in a clinical setting yet, but these studies could provide a good starting point for objective pain assessment in ridden horses.

Influence of personality characteristics and other factors on pain expression

Thus far, very little attention has been paid in the currently described pain scales to the influence of personality, stress or coping style on pain in horses. In the pilot study by Dalla Costa et al. (2017), the influence of positive and negative emotional states such as fear or anticipation of a food response were assessed. Ijichi et al. (2013) showed that determining personality and/or individual coping styles may have major implications for the accurate assessment of pain in horses. In a review by König v. Borstel et al. (2017) the close relationship between behavioural indicators of stress and/or pain and/or conflict and/or anxiety (Reid et al., 2017) were shown. These functional types of behaviour could be difficult to disentangle – especially in Composite Pain Scales – and therefore could lead to misinterpretation. Conflict behaviour could be of importance if horses are evaluated either when being in groups or in relation to a socially not preferred conspecific visible in a neighbouring box. For ridden horses, it could be important if horses are brought into situations of conflict with their rider when for example opposed or conflicting commands are given during training or competition (Williams and Tabor, 2017). Wagner (2010) describes the possible effects of stress on homeostasis and on the expression of pain in horses. Future studies should ideally be directed to further assess the possible influence of these aspects on pain behaviour in horses.

Future possibilities for more objective quantification of pain

Recent improvements in digital technology show that collaboration of veterinary scientists and information technology scientists can lead to further innovative techniques that will enable objective pain recognition. In sheep, computerised technology already has shown to be able to enhance pattern recognition in facial expression in sheep with acute pain (Hutson, 2017; Lu et al., 2017) and these technologies are being explored in other species as well. As in various other fields, technologies in veterinary medicine follow developments in human medicine, where information technology has already made its entrance in digital patient recognition and determination of pain states based on speech and facial expression (Shamim Hossain, 2016).

Conclusions

If we compare the rather pessimistic view regarding the scientific fundaments of objective pain recognition in horses that was described after the turn of the century to the current state of scientific publications on equine pain recognition, the times have changed. There is abundant public interest in the topic and new publications have emerged in relatively large numbers, although more effort should be put into further and better validation of the current pain scales themselves. Based on the published studies on pain recognition in horses so far, facial expression-based pain scales seem to be very promising for valid and quick pain assessment in box rested horses with acute pain from various origins. These pain scales can be implemented into daily clinical practice, based on the minimal time that is required to score horses and their valid and reproducible outcomes. Composite pain scales require more time and are based on more extended ethograms, but can also be very useful in clinical or research conditions for the assessment of acute pain in horses and to assess the effect of an intervention or treatment in horses with acute pain. More effort should also be put into validation of existing pain scales for more specific painful conditions; the available composite and facial expression-based pain scales already described provide a very good scientific basis for this and could be used in their current form to undergo validation for more types of clinical pain to increase practical applicability. Once validated, pain scales can be used to assess pain in horses and the availability of tools to assess pain in moving and ridden horses will possibly further improve wellbeing of sports horses. New studies that will objectively and validly assess chronic pain in horses and studies that will describe the validity of these new scales when used by horse owners and trainers could further improve this wellbeing. Furthermore, these pain scales can be used in future studies to assess clinical efficacy of new analgesic drugs and techniques that will further increase the treatment options for horses with pain.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

Appendix: Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.tvjl.2018.10.001.

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