CODE OF PRACTICE FOR THE CARE AND HANDLING OF EQUINES:

REVIEW OF SCIENTIFIC RESEARCH ON PRIORITY ISSUES

Equine Code of Practice Scientific Committee

October 2025

- Kathleen MacMillan, MSc, DVM, DABVP (Eq) (Chair)
  Associate Professor
  Department of Health Management
  University of Prince Edward Island
  Canadian Veterinary Medical Association

- Katrina Merkies, PhD
  Professor, Department of Animal Biosciences
  University of Guelph
  International Society for Applied Ethology
  International Society for Equitation Science

- Carissa Wickens, PhD
  Associate Professor, Department of Animal Sciences
  University of Florida
  International Society for Applied Ethology
  International Society for Equitation Science

- Robert J. (Bob) Coleman, PhD, PAS
  Associate Professor
  Department of Animal and Food Sciences
  University of Kentucky
  American Society of Animal Science

- W. Michael Scott, DVM, MVSc, DACVS & DACVSMR
  Assistant Professor
  Department of Veterinary Medicine
  University of Calgary
  Canadian Veterinary Medical Association

- Bettina Bobsien, DVM BSA DABVP (Ex officio)
  Equine Code Development Committee Chair
  Canadian Veterinary Medical Association

- Cordy DuBois, PhD
  Scientific Research Writer

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EXCERPT FROM THE SCIENTIFIC PANEL TERMS OF REFERENCE

Background

It is widely accepted that animal welfare codes, guidelines, standards or legislation should take advantage of the best available knowledge. This knowledge is often generated from the scientific literature.

In re-establishing a Code of Practice development process, NFACC recognized the need for a more formal means of integrating scientific input into the Code of Practice process. A Scientific Committee review of priority animal welfare issues for the species being addressed will provide valuable information to the Code Development Committee in developing or revising a Code of Practice. As the Scientific Committee report is publicly available, the transparency and credibility of the Code is enhanced.

For each Code of Practice being developed or revised, NFACC will identify a Scientific Committee. This committee will consist of a target number of 6 scientists familiar with research on the care and management of the animals under consideration. NFACC will request nominations from 1) Canadian Veterinary Medical Association, 2) Canadian Society of Animal Science, and 3) Canadian Chapter of the International Society for Applied Ethology. At least one representative from each of these professional scientific bodies will be named to the Scientific Committee. Other professional scientific organizations as appropriate may also serve on the Scientific Committee.

Purpose & Goals

The Scientific Committee will develop a report synthesizing the results of research relating to key animal welfare issues, as identified by the Scientific Committee and the Code Development Committee. The report will be used by the Code Development Committee in drafting a Code of Practice for the species in question.

The Scientific Committee report will not contain recommendations following from any research results. Its purpose is to present a compilation of the scientific findings without bias.

The full Terms of Reference for the Scientific Committee can be found within the NFACC Development Process for Codes of Practice for the Care and Handling of Farm Animals, available at www.nfacc.ca/code-development-process#appendixc.

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Equine Code of Practice Scientific Committee Report
October 2025

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1 Pain Recognition

CONCLUSIONS

1. **Pain behaviours in equids are often non-specific (e.g., heart rate), situation-dependent (e.g., kicking at abdomen in response to colic), and are affected by the presence of an observer.**

2. **Many behavioural scales currently exist to evaluate pain in equids, focusing on a small number of physiological measures (e.g., heart rate), overall body posture, facial expressions, and the prevalence of unusual or abnormal behaviours.**

3. **Though owners and professionals working with horses (e.g., trainers, barn managers) believe horses feel pain, they may not be able to correctly identify it.**

4. **Pain scales specific to non-horse equids (e.g., donkeys) are less common and need further validation.**

Pain, and subsequently pain management, plays an important role in welfare. Horses have the potential to experience many painful conditions throughout their lifetime, including but not limited to: orthopedic pain (e.g., laminitis, Hunt, 2002; Bardell, 2017), abdominal pain (e.g., colic, Ashley et al., 2005), dental pain (Ashley et al., 2005), surgery-related pain (e.g., Gleerup & Lindegaard, 2016; castration, Ashley et al., 2005), and disease-related pain (osteoarthritis, Howard et al., 2024). They may also experience pain as a result of being ridden or driven, such as tack or rider-caused back pain, (Dyson et al., 2015; Domańska-Kruppa et al., 2024), bit-related pain or oral lesions, Mellor, 2020; Tuomola et al., 2024) and bruising caused by high rein tension (Tuomola et al., 2024). Additionally, horses are traditionally ridden, trained, and handled using negative reinforcement (i.e., the removal of a potentially aversive stimulus when the desired behaviour is performed, such as relieving pressure on a lead rope when the animal moves forward), a strategy that has the potential to cause pain when paired with or inadvertently turned into punishment (McGreevy & McLean, 2009).

Pain control in equids can take a myriad of forms, including nonsteroidal anti-inflammatory drugs (NSAIDs; e.g., phenylbutazone or "bute," flunixin, meloxicam), alpha-2 agonists (e.g., xylazine), opioids (e.g., fentanyl), N-Methyl-D-aspartate receptor antagonists (e.g., ketamine), and a range of local anesthetics such as nerve blocks (Goldberg & Shaffran, 2014). To appropriately treat and mitigate pain, however, it must be recognized by the caregiver, owner, or veterinarian.

1.1 Measuring and Assessing Pain: Physiological and Behavioural Measures

There are a multitude of methods to measure and evaluate pain in equids. Beginning with purely physiological signs, research has commonly utilized heart rate, respiratory rate, circulating endogenous cortisol/corticosteroids, β-endorphins, and catecholamines to measure pain indirectly, typically on equids undergoing surgery (as reviewed in de Grauw & van Loon, 2016).

With respect to acute pain, non-invasive blood pressure has been utilized (Gleerup & Lindegaard, 2016), and pro-inflammatory mediators have also been used as markers of inflammation (e.g., as in de Grauw et al., 2009a, 2009b), even when associated pain severity is undetermined. Overall, however, physiological measures in horses are non-specific, meaning changes reported may be a response to pain, but may also be a response to fear, stress, or other factors such as dehydration and disease (de Grauw & van Loon, 2016). Moreover, these confounding factors also make determining the severity of pain utilizing only physiological measures a significant challenge (de Grauw & van Loon, 2016), as horses undergoing painful procedures may not show significantly different physiological parameters than their control counterparts (e.g., Price et al., 2003).

Whether in conjunction with physiological measures or on their own, there also exist many detailed behavioural ethograms describing equine pain in response to different scenarios, as reviewed by Ashley et al. (2005), who divided pain behaviours into four broad categories: non-specific indicators, behaviours related to abdominal pain, behaviours related to foot or limb pain, and behaviours related to head or dental pain. To illustrate some of the different ways pain can manifest in response to different situations, Table 1.1 briefly outlines some examples of equid behaviours as reviewed in Ashley et al. (2005). It is important to note that this list is not exhaustive, and many other indicators exist beyond those mentioned here, such as back pain (Rochais et al., 2015).

Table 1.1: Examples of pain behaviours as demonstrated by equids categorized by type

Category of Pain Behaviours	**Behavioural Examples**
Non-specific	- Considerable restlessness, agitation, and anxiety - Rigid stance and reluctance to move - Lowered head carriage - Fixed stare and dilated nostrils, clenched jaw - Aggression towards handlers, other horses (e.g., own foal), self, or objects
Abdominal pain	- Vocalization (deep groaning) - Rolling - Kicking at abdomen - Flank watching - Stretching - Dullness and depression
Foot or limb pain	- Weight-shifting between limbs - Limb guarding - Abnormal weight distribution - Pointing, hanging, and rotating limbs - Abnormal movement (e.g., attempts to lie down) - Reluctance to move
Head or dental pain	- Headshaking - Abnormal oral behaviour

	- Altered eating, anorexia, quidding, food pocketing - Head tossing (Thomson et al., 2020; as described during riding)

Alongside specific behaviours, overall changes in behaviour time budgets (i.e., the time spent by the equid performing certain behaviours such as resting, eating, etc.) have also been cited as potential indicators of pain (Ashley et al., 2005). Utilizing these indicators, researchers have put together behaviour-focused pain assessments (Price et al., 2003; Sutton et al., 2013; Pehkonen et al., 2019; Oliveira et al., 2021 [donkeys]; Trindade et al., 2021) as well as a discomfort ethogram (Toricivia & McDonnell, 2021). These pain assessments can involve examining the animal as a whole or focusing on more specific areas of the horse (e.g., limbs). For example, when examining an animal post-surgery, the whole equid can be observed to record both the prevalence and duration of normal behaviour (such as standing and eating) as well as abnormal behaviours like unusual weight shifting, excessive licking, and wobbling locomotion, as seen in Price et al. (2003) using a defined ethogram. Oliveira et al. (2021) and Trindade et al. (2021) utilized a similar approach, creating an ethogram based on extensive literature to capture the full range of behaviour pre- and post-castration surgery. In comparison, when asking owners to evaluate the behaviour of their own horses after a dental surgery, Pehkonen et al. (2019) focused only on behaviours most likely to be affected by the surgery, which in this case were related to eating and drinking (e.g., pocketing food, reluctance to drink cold water), rather than evaluating the entire animal.

Behavioural pain assessments may also use known painful situations (e.g., castration) to record and evaluate all behaviours exhibited by equids in response. In the discomfort ethogram, Toricivia and McDonnell (2021) focused on clearly defining all signs of potential discomfort from video footage of horses regarded as normal and healthy and horses admitted as patients to a veterinary hospital, noting that no one behaviour was singularly indicative of discomfort. Instead, discomfort was best evaluated by the presence of clusters of these behaviours, where the frequency and combination of behaviours provided more valuable information than each on its own (Toricivia & McDonnell, 2021). Toricivia and McDonnell (2021) also noted that horses had individual responses to discomfort and could have their own unique profile of behaviour combinations even in response to the same situation.

As with physiological measures, behavioural assessments are not without their challenges. Strictly behavioural assessments require significant time (Ashley et al., 2005) as well as baseline knowledge or observation from before the painful experience to appropriately gauge the animal's response (de Grauw & van Loon, 2016). Researchers have used owner-directed questionnaires to capture perceptions of their horse's overall behaviours in an effort to benefit from the owner's familiarity. Howard et al. (2024) was able to distill a pain behaviour questionnaire to a series of fifteen questions, asking owners to evaluate the standing posture, head and neck position during eating, ear and eye positions, movement, and overall behaviour and attitude. This questionnaire was taken by owners of horses with diagnosed osteoarthritis as well as used to evaluate five control horses. Owner self-report is not without its own biases; however, questionnaires like this act as a bridge between more scientific pain behaviour ethograms and scales intended for use by the average horse owner and warrant further investigation as subsequent validation studies are conducted (Howard et al., 2024).

Additionally, like strictly physiological measures, behavioural measures can also be non-specific and may be a result of other factors, such as the novelty of the environment (de Grauw & van Loon, 2016), restraint, or even anticipation of a painful experience (Wagner 2010; Hall & Kay, 2024). Finally, most behavioural assessments are designed to be conducted while the horse is stalled and readily accessible to the observer, which can offer its own unique challenge. Equids, as a result of being prey animals, will generally respond to an observer's presence by reducing their expression of pain behaviours, as noted by Price et al. (2003). In a more experimental setting, Toricivia and McDonnell (2020) were able to quantify changes in expression of pain or discomfort behaviour by animals housed at an equine hospital post-surgery. Utilizing 24-hour video surveillance, researchers recorded the occurrences of discomfort behaviours (e.g., leaning against objects, atypical recumbency) of equine patients and saw a significant decrease in the frequency of these behaviours upon caretaker approach, including a complete cessation of these behaviours in 30% of horses. The effect of human presence, therefore, should not be underestimated with regard to the expression of pain behaviours matching pain intensity.

The link between pain intensity and associated pain behaviours is not always one-to-one. In work involving comparisons between tissue damage and lameness scores, Ijichi et al. (2014) noted that a horse's personality, measured in neuroticism (e.g., anxious predisposition), extroversion (e.g., proactive response to novelty), stoicism, and tolerance, had more of an effect on the lameness scores than their associated tissue damage. In essence, horses that showed more neuroticism were more likely to show more lameness behaviours despite having a lower level of tissue damage, and the opposite was true for low extroversion horses (i.e., a low lameness score for a comparably high level of tissue damage; Ijichi et al., 2014). The effect of personality, as well as coping style, on pain is not well understood in horses and other equids, despite the recognition that individuals and breeds exhibit different personality types (Lloyd et al., 2008; National Academies of Sciences, Engineering, and Medicine, 2021).

1.2 Measuring and Assessing Pain: Pain Scales

The inherent weaknesses of utilizing solely physiological or behavioural measures have resulted in the creation of more specific pain scales for use on equids, many of which have been tested and refined through multiple iterations on a variety of different types of pain. There are three clusters of similar pain scales that have the highest prevalence within the literature: the composite pain scale, facial assessment scales, and the ridden horse ethogram. They are referred to as "clusters" due to their methodological similarities, though the scales themselves may not be identical if researchers made adjustments due to the findings of their predecessors to improve the validity, reliability and/or repeatability of each scale's iterations. These types of scales were reviewed in 2018 by van Loon and van Dierendonck, with additions from research that has been published since that review.

1.2.1 Composite Measure Pain Scales

The first of these clusters, the composite measure pain scale is, as the name suggests, a scale which utilizes multiple measures, typically both physiological and behavioural. While not defined as a composite measure pain scale within the published article, Pritchett et al. (2003)

exemplify this combination approach, where researchers examined physiological data (heart rate, respiratory rate, plasma cortisol concentration) alongside behavioural data to evaluate pain behaviours in a control group (n=10), a group that only experienced anesthesia (n=10), and a group that underwent surgery (n=7). Composite pain scales are used frequently in equine research (Pritchett et al., 2003; Sellon et al., 2004; Bussières et al., 2008; Dutton et al., 2009; Sanz et al., 2009; Lindegaard et al., 2009, 2010; van Loon et al., 2020, 2014; Graubner et al., 2011; Pader et al., 2011; Sutton et al., 2013; Minghella & Auckburally, 2014; Taffarel et al., 2015; Urayama et al., 2019; Lawson et al., 2020; Barreto da Rocha et al., 2021; Lanci et al., 2022 [foals specifically]; Trindade et al., 2023) and offer considerable insight into the full body experience of pain. Physiological measures used in a composite pain scale are typically heart and respiratory rates, while behavioural measures focus on the horse's posture, appetite, recumbency, and response to human interaction. Selected research utilizing composite measure pain scales has been summarized below (Table 1.2).

Table 1.2: Composite measure pain scales summary

Authors	Type of Pain	Physiological Measures	Behavioural Measures
Pritchett et al., 2003	Post-operative (surgery for acute gastrointestinal disease)	heart rate, respiratory rate, plasma cortisol concentration	active, locomotion, pain, resting behavioural categories (ethogram)
Sellon et al., 2004	Post-operative (celiotomy)	heart rate, respiratory rate, rectal temperature, gastrointestinal auscultation score, frequency of fecal passage, plasma cortisol concentration, body weight	pain behaviours, head position, ear position, location in stall, spontaneous locomotion, response to opening the stall door, response to circumstances (e.g., approach) (numerical scale)
Bussières et al., 2008	Orthopedic pain	heart rate, respiratory rate, digestive sounds, rectal temperature	interactive behaviour, response to palpation, general appearance, sweating, kicking at abdomen, pawing, posture, head movement, appetite (numerical scale)
Dutton et al., 2009*	Hoof pain	heart rate, respiratory rate, digital pulse, muscle fasciculation	standing behaviour, walking behaviour, handling behaviour, sweating, head-tossing, willingness to move, lying behaviour (numerical and sequential, stacking scale)
Sanz et al., 2009	Castration (post-operative)	heart rate, respiratory rate, rectal temperature, gastrointestinal tract motility, fecal output, water and hay consumption	gross pain behaviours, head position, ear position, location in stall, spontaneous locomotion, response to approach, lifting feet, response to provision of grain, standing/recumbency (visual analog scale and numerical rating scale)

Lindegaard et al., 2009	Hot iron branding and microchip injection	heart rate, skin temperature, skin sensitivity, edema, serum amyloid A and cortisol concentrations	reaction-based numerical behaviour score and visual analog scale (based off of Pritchett et al., 2003)
Lindegaard et al., 2010	Induced radiocarpal synovitis	heart rate, general appearance and color of mucous membranes, capillary refill time, auscultation of the abdomen, rectal temperature, respiratory frequency	lameness, gross pain behaviour, weight bearing, head position, location in stall, response to open door, response to observer approach (combined into single pain score; adapted from Pritchett et al., 2003)
van Loon et al., 2014	Chronic pain	heart rate, breathing rate, borborygmi, rectal temperature	general appearance, body posture, weight distribution, weight shifting, head carriage, eating, changes in behaviour towards other horses, facial expressions (numerical scale)
van Loon et al., 2020	Induced synovitis	heart rate, respiratory rate, rectal temperature	eating, walking, standing still, lying down, rolling, shifting weight (ethogram—frequency and duration), reactions to palpation (numerical scale)
Graubner et al., 2011	Post-operative (abdominal surgery)	heart rate, respiratory rate	general subjective assessment, postural behaviour, interactive behaviour, response to food, colic behaviour, stimulation of muscles, reaction to palpation of incisional area (numerical scores, summed for total score)

Pader et al., 2011	Post-operative (elective bilateral ovariectomy)	heart rate	activity levels, numerical rating scale focused on posture and socialization; based off of Pritchett et al., 2003, and Sellon et al., 2004
Taffarel et al., 2015	Castration (post-operative)	heart rate	posture, interactive behaviour, appetite, activity, palpation, miscellaneous
Urayama et al., 2019	Induced inflammatory response	heart rate, body temperature, respiratory rate, behavioural pain score, hoof wall surface temperature, plasma tumor necrosis factor-alpha, cortisol, leukocyte counts	gross pain behaviours, head position, ear position, location in stall, spontaneous locomotion, interactions, response to grain (numerical scale; adapted from Pritchett et al., 2003)
Lawson et al., 2020	Colic	heart rate, respiratory rate	pain face, gross pain behaviour, activity levels, location in stable/pasture, head position, attention to painful area, interaction, response to food
Barreto da Rocha et al., 2021	Post-operative (extensive list of procedures including those performed on limbs, teeth, vocal cords, and castration)	heart rate, respiratory rate, digestive sounds, temperature	uses pain scale developed by Taffarel et al., 2015, and Bussières et al., 2008
Lanci et al., 2022**	General (foal-focused)	heart rate, rectal temperature, respiratory rate, intestinal motility	facial expression items, behavioural items (posture, appetite, lameness), reaction to palpation
Trindade et al., 2023	Orthopedic and soft-tissue surgical	N/A—only used behavioural scales from previously	uses pain scale developed by Taffarel et al., 2015, and Bussières et al., 2008

		developed composite pain scales	
van Dierendonck et al., 2020	Donkeys (acute pain)	respiratory rate, heart rate, rectal temperature, sweating, digestive sounds	overall appearance, pain sounds, posture, changes in behaviour of companion/group, weight distribution, eating, laying down/rolling, movement, head carriage, position of ears, reaction to observer, tail flicking, reaction to palpation, kicking at abdomen, pawing at floor
Medeiros do Nascimento et al., 2023	Donkeys (post-inguinal orchiectomy)	Heart rate, respiratory rate, rectal temperature, acute phase proteins	uses pain scale developed by Taffarel et al., 2015, and Oliveira et al., 2021

* *Case study*
** *Pilot study*

As demonstrated in Table 1.2, composite measure pain scales, while utilizing similar physiological measures and behaviour scales, are rarely identical, which makes comparisons between them challenging. Ethograms for pain behaviour, while similar, are equally diverse, with some limited to a small number (≤ 5) of behaviours (e.g., Pritchett et al., 2003; Sellon et al., 2004) while others utilize a larger number of behaviours and/or a numerical scale for evaluation (versus an ethogram, e.g., van Loon et al., 2014). In some cases, behavioural and/or physiological scores can be tallied into a single pain scale value assigned to the animal (e.g., Sellon et al., 2004; Bussières et al., 2008). From a more critical standpoint, composite measure pain scales require well-trained observers (as well as capable lab technicians), and the scale must be built upon strong research and well-validated (de Grauw & van Loon, 2016).

1.2.2 Facial Assessment Scales

The second cluster, facial assessment scales, refers to a number of scales which have been devised to determine the intensity of equid pain by solely examining the face and related structures (e.g., ears for ear position). While facial assessment scales for pain are primarily used in research, the use of facial expressions to determine equid pain has been reported outside of experimental settings. Owners in Bosnia and Herzegovina, for example, despite being unfamiliar with pain scales, reported they most used facial expressions and demeanour to assess pain (Spahija et al., 2023). Understanding this expressivity, Wathan et al. (2015) documented the myriad of ways in which the muscles of a horse's face could move (e.g., pulling the corner of the lip, closing the eye), highlighting the complexity of facial expressions in horses and their potential for use in pain evaluation.

Following the development of comparable scales for rodents and rabbits, Dalla Costa et al. (2014) created the Horse Grimace Scale (HGS), a facial assessment scale which scored six clearly-defined facial action units: stiffly backward ears, orbital tightening, tension above the eye area, prominent strained chewing muscles, mouth strained + chin pronounced, and strained nostrils + flattening of the profile. With a 73.3% detection accuracy in horses experiencing post-castration pain and a high inter-observer reliability (Intraclass Correlation Coefficient = 0.92), the HGS was recognized as a potential candidate for assessing other types of pain (Dalla Costa et al., 2014). The HGS has subsequently been used in other research studies with success when identifying acute laminitic (Dalla Costa et al., 2016) and dental (Coneglian et al., 2023) pain, but with little to no success identifying gastric pain (Ferlini Agne et al., 2023). It has also been used as the basis for developing other, similar facial expression evaluation scales to measure experimentally induced inflammatory pain (Carvalho et al., 2022), which also was not significantly successful. The HGS continues to be redefined (Werner et al., 2024), with facial action units described in more anatomical terms in an effort to improve reliability, but such changes may make it difficult for the scale to be applied outside of research.

Recently, the grimace scale has also been applied to donkeys (Orth *et al.* 2020), which considered similar facial action units such as ear position, nostril/muzzle tension, eye shape, and orbital tightening, as well as evaluated overall stance and appearance. As with Dalla Costa et al. (2014), the scale was tested on donkeys post-castration to evaluate pain and measure scale sensitivity, specificity, and accuracy, which ranged from 36.91% to 64.25% depending on the measure (Orth et al., 2020). Overall, abnormal stance and general appearance scored the highest in all three categories (>60%), but further research is required before this tool can be reliably utilized on donkeys (Orth et al., 2020). Donkeys in particular offer a unique challenge with regard to behaviour-based scoring, as donkeys are reported to display more subtle signs of pain and the pain behaviours described in horses may not be useful indicators of pain in donkeys (reviewed by Ashley et al., 2005).

While they are not referred to as facial action units, the Equine Utrecht University Scale for Facial Assessment of Pain (EQUUS-FAP) takes a similar approach to the grimace scale. The scale evaluates head movement, eyelid position, eye focus, nostril relaxation, relaxation of the corners of the mouth/lips, head muscle tone, flehmen responses and/or yawning, teeth grinding or moaning, and ear position (van Loon & van Dierendonck, 2015). The EQUUS-FAP showed high sensitivity (87.5%), specificity (88.0%), as well as high inter-observer reliability (Intraclass Correlation Coefficient = 0.93) when tested on horses experiencing colic pain (van Loon & van Dierendonck, 2015). The scale was subsequently successfully validated using colic pain again (van Dierendonck & van Loon, 2016), and then again when assessing horses experiencing a variety of head-related pain (e.g., dental, ocular, post-operative, trauma; van Loon & van Dierendonck, 2017). Preliminary research has also been conducted on a donkey version, called EQUUS-DONKEY-FAP, with similar success (van Dierendonck et al., 2020).

The act of riding has the potential to significantly compromise the use of entirely expression-based facial pain scales, and as such an ethogram designed specifically for ridden horses was developed by Mullard et al. (2016). This ethogram shares similar features with other facial expression scales (e.g., eye expression, ear position) but also incorporates salivation, tongue position, head position, and head verticality (Mullard et al., 2016). Mean inter-observer reliability was reported at 69%, but researchers also noted lower reliability in observers' ability to score certain facial expression categories (e.g., muzzle flattening) when compared to the HGS (Mullard et al., 2016).

As artificial intelligence improves, so does the potential for image scanning programs to be taught how to recognize pain from photographs or videos, with a particular focus on facial pain assessment scales due to their frequent usage. Though still an area of research in development, initial promising results for assessing both emotional states and pain have been reported using a variety of exploratory models (Andersen et al., 2018, 2021; Corujo et al., 2021; Lencioni et al., 2021; Broomé et al., 2022; Feighelstein et al., 2024). It is, however, currently hindered by a lack of data sets available for the development and teaching of artificial intelligence-powered models (Chiavaccini et al., 2024).

1.2.3 Ridden Horse Pain Ethogram

Horses are not always standing still or in a stalled environment when they are experiencing pain, and this was the impetus for the third cluster, the Ridden Horse Pain Ethogram, to be devised to help evaluate pain during ridden activities. The Ridden Horse Pain Ethogram (first published by Dyson et al. in 2018) is an assessment scale that utilizes twenty-four defined behaviours that focus on head position, ear position, eyes, mouth and tongue position, tail activity, gait, overall movement, and rear/bucking. Since its conception, it has been tested by Dyson and colleagues on dressage horses (Dyson & Pollard, 2021a, 2021b; Dyson et al., 2022), eventing horses (Dyson & Pollard, 2022), riding school horses (Dyson & Pollard, 2020), and horses experiencing lameness-related pain (Dyson & van Dijk, 2020; Dyson et al., 2020; Dyson & Pollard 2023), as well as by other researchers seeking to validate it further (Garcia et al., 2022; Pineau et al., 2024). The potential for many external factors to affect the Ridden Horse Pain Ethogram have been extensively discussed, including the difficulty in fully removing scorer bias (Dyson & Pollard, 2020) and the possible effects of rider size, skill, equipment fit, and pre-existing conditions on the final score (Berger et al., 2022; Ladewig et al., 2022). A pilot study on Icelandic horses by Garcia et al. (2022) also highlighted the importance of ensuring the scale can be applied to gaits other than walk, trot, and canter (e.g., tolt). While the ease of use and reliability of this scale has been well demonstrated, it would benefit from more validation studies conducted like the one by Dyson and van Dijk (2020), where anesthesia was shown to decrease the pain scores of horses, rather than relying solely on lameness as an indicator of pain.

1.2.4 Scales in Development

Historically, pain evaluation and pain assessment scales have focused on horses post-surgery; however, this is not the only source of pain a horse may experience in their lifetime. Thus, scales which are applicable to other sources of pain (e.g., chronic pain) have begun to emerge.

Chronic pain in particular has started to garner interest, due to its relationship with quality of life. To that end, two scales have been devised: one related to non-specific chronic pain (horses, van Loon & Macri, 2021; donkeys, van Loon et al., 2024) and two specifically for chronic musculoskeletal pain (Auer et al., 2023; Howard et al. 2024). For both scales, researchers combined the full-body assessment of a composite pain scale with a facial pain assessment scale and showed preliminary success in identifying pain in horses and donkeys with chronic pain conditions. There have also been attempts to create scales for previously subjective assessments, as in the case of a scale to assess and grade back pain, developed by Mayaki et al. (2020), as well as understudied pain such as ophthalmic pain (Ortolani et al., 2021; Nannarone et al., 2023).

Furthermore, in an effort to simplify the more extensive composite pain scales, and to provide a scale that requires relatively little training, Maskato et al. (2020) created a descriptive scale utilizing 9 pain behaviours on an increasing scale of severity (e.g., flank watching was given a score of 1 and considered mild, and rolling was given a score of 5 and considered severe) that they validated against a visual analog scale and the horse's medical results after clinic admission for abdominal pain.

All scales in development require further research to validate their wider use, while supporting the range and specificity of pain behaviours exhibited by equids. Furthermore, they also highlight the necessity of scales being feasible to use on-farm if they are to serve a wider purpose beyond research.

1.3 Measuring and Assessing Pain: Pain Identification

An understanding of what causes equids pain, as well as the signs of pain in equids, can help individuals better care for their animals. Identifying pain in horses is faced with two main challenges: first, that prey animals typically display subtle signs of pain (Burden & Thiemann, 2015; Gleerup 2018; Taylor et al., 2002, applicable to both horses and donkeys) and second, that not all pain manifests as the same behavioural or physiological symptoms (de Grauw & van Loon, 2016). Pain identification may also be further complicated by more human factors. For example, Hausberger et al. (2021) reported that owner perception of what constitutes good welfare in horses (including the absence of pain) can be negatively impacted by a number of factors, including anthropomorphism, cultural biases, popular beliefs, and a general undervaluing of welfare as a whole.

When surveying horse owners in the Brazilian and the Canadian equine industry, 94% and >95%, respectively, indicated they believed horses could feel pain (Hötzel et al., 2018; DuBois et al., 2018). Similarly, when interviewing donkey owners in Pakistan, Bukhari et al. (2023) found that the majority (81.3%) believed donkeys could feel pain. The possibility of equids experiencing pain is, therefore, considered well-understood by individuals within the industry; however, this does not always translate directly into awareness or actions of care. Though 81.3% of owners believed their donkeys could feel pain, this high number was reflected neither in how many owners used padding under saddles nor how many indicated they provided food and water during the working day (Bukhari et al., 2023). Though not specific to pain, Horseman et al. (2017) reported that owners downplayed the welfare severity of situations that mirrored their own husbandry practices, something which may have the potential to impact the dichotomy of owner belief in equine pain and management practices.

Expert opinion offered by industry participants in the United Kingdom indicated that an inability to recognize pain was a significant equine welfare issue (Rioja-Lang et al., 2020), a conclusion also supported by Watney et al. (2024) when surveying the knowledge of horse owners worldwide. More practically, of owners surveyed about back pain in their horses (n=161), only 11.8% reported their horses had back pain, versus the 49.7% of horses that were identified as having back pain by manual palpation by an experienced chiropractor or static surface electromyography (Lesimple et al., 2013). Ireland et al. (2012) also found that owners significantly under-reported dental problems (24.5% by owners versus 95.4% by veterinary exam), cardiac murmurs (0.5% by owners versus 20% by veterinary exam), lameness (23% by owners versus 50% by veterinary exam), and hoof abnormalities (27% by owners versus 80% by veterinary exam) in their geriatric horses. This phenomenon is not limited strictly to pain. When utilizing videos of horses exhibiting signs of distress, members of the equine industry reported some of these individuals as experiencing positive affective states, even when experts scoring the same videos reported only negative affective states (Bell et al., 2019). Additionally, even if participants in this study indicated the horse was experiencing a negative affective state, a statistical minority would still allow their horses to be treated in such a manner (Bell et al., 2019). This may be due to the fact that pain-related behaviours are frequently classified as "naughtiness" in horses (Rioja-Lang et al., 2020). Work by Merkies and Trudel (2024) further supported by the findings of Bell et al. (2019), where survey participants scoring videos were only able to match expert scores of a horse's affective state 52.5% (n = 534) of the time. Merkies and Trudel (2024) also noted that participants were less successful identifying more subtle signs of both positive and negative affect.

Opinion also varies between individuals as to which practices are considered painful, as well as how much pain an animal can experience before veterinary intervention is necessary. Sellon et al. (2021) reported significant differences in pain severity perception between owners and equine veterinarians when presented with the same scenarios (castration, subsolar abscess, laceration, gas colic, pastern fracture, dental float, as well as a selection of veterinary procedures and surgeries). Veterinarians consistently scored some scenarios (e.g., subsolar abscess) higher than owners, while the opposite was true in other scenarios (e.g., pastern fracture), culminating in a wide range for both groups even within the same scenario (Sellon et al., 2021). Despite this, the majority of horse owners surveyed (87.7%, n=533) reported that they felt confident in their own ability to assess pain and 91.2% were confident in their veterinarian's ability to assess pain (Sellon et al., 2021). Price et al. (2002) also reported large variance in perception of pain severity by veterinarians when ranking the severity of castration, traumatic soft tissue injury, mild acute laminitis, severe acute laminitis, solar abscess, and acute tendonitis. When examining analgesic choices, Price et al. (2002) also noted that veterinarians indicated potency as their most important deciding factor but did not choose analgesics with the highest research-supported potency, suggesting that their decisions instead were based on personal experience with the analgesic.

Furthermore, multiple researchers have examined owner self-report regarding care of colicking horses and noted that owners not only lacked basic knowledge (e.g., normal resting heart rate; Bowden et al. 2020) but also would only seek veterinary assistance when colic symptoms were extreme (Bowden et al., 2020; Costa et al., 2022). A similar phenomenon has also been described by Dixon et al. (2000), who noted that owners also tend to seek help for their horse's dental pain only when it has reached an advanced stage.

1.4 Future Research

1. Factors affecting individual expression of pain (e.g., temperament), including coping style, need to be further researched to better understand equid pain expression.
2. Further development and modification of pain assessment scales such that they can be used by owners, caretakers, and veterinarians on-farm needs to be conducted to increase the usefulness of pain assessment scales beyond research.
3. Further development of pain assessment scales, or testing of existing scales, should be conducted on painful situations other than post-surgery, such as chronic pain.
4. Further validation of pain scales for donkeys is needed.

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2 Castration

CONCLUSIONS

1. **Castration is a surgical technique with a variety of methods that make viable comparisons between research studies challenging. There is no clear evidence as to which technique is the preferred method.**

2. **The definition of a complication is also inconsistent, resulting in overall complication incident rates that range from 6.9% to 60%. The most common complications are swelling and fever, and the incidence of potentially fatal complications (e.g., major hemorrhage) is low. However, castration is not without significant risks, and as it is an elective procedure these risks must factor into decisions regarding care.**

3. **Castration is a painful procedure. Species-specific perioperative and post-operative pain management is necessary.**

2.1 Castration Methods

Castration is an elective surgery performed on equids for a variety of reasons, including safety for handling and ease of management individually and in groups (Green, 2001). Use of the animal (e.g., for sport) and incidence of unwanted behaviour factor heavily into the age at which equids are castrated (Green, 2001), but the ideal age for castration is determined predominantly by the size of the testes, presence of sexual behaviour, and the risk of undiagnosed health concerns (e.g., hernia) in younger animals (Woodford, 2020). Preliminary research found no significant long-term effects on osteoarticular development (Rouge et al., 2023) and behaviours (Cognie et al., 2022) in horses castrated as young as three days old. Castration after three years of age, however, is recognized as adding significant risks to the procedure (Green, 2001; Hodgson & Pinchbeck, 2019)**.** There is no singular method of castration, and Owens et al. (2018a) report that there is an overall lack of "optimal surgical technique or peri-operative protocol." The methods themselves differ with respect to complications, risk, costs, and aftercare (Mason et al., 2005; Robinson et al., 2023), with some methods reported more frequently than others. In short, equine castration can be conducted in a hospital environment or in-field (typically at the farm where the horse is located), while the horse is standing or recumbent, and utilizing one of three main techniques: open, closed, or half-closed (Searle et al., 1999; Green, 2001).

Despite the fact that these three technique names are commonplace, their definitions are not always consistent (Green, 2001; Rodden et al., 2024). The terms "open," "closed," and "half-closed" refer to the state of the tunica vaginalis (a membrane pouch surrounding the testis) during the procedure. This pouch can be cut open prior to the application of emasculators (open) or not opened by placing the emasculator over the tunic containing the testes and vessels (closed); however, some individuals still regard a castration where the tunica vaginalis is opened first and then closed afterwards to be a closed method (Green, 2001). Half-closed (sometimes referred to as semi-closed or modified open) involves a more selective opening of the tunica vaginalis, as the name suggests (Green, 2001). In addition, there is documentation on the exploratory use of a subcapsular technique (castration performed by an incision in the scrotum; Ibrahim et al., 2021) as well as parascrotal access (castration performed by incision in the lateral region of the scrotum; Barrêto et al., 2022), both in donkeys.

Alongside these techniques, castration involves the use of some type of emasculator, which can take the form of cutting only, cutting and crushing (Comino et al., 2018), or torsion of the spermatic cord using a tool known as the Henderson instrument (Owens et al., 2018a). Ligature use is possible and strongly recommended in donkeys and mules (Sprayson & Thielmann, 2007) and older horses (Hodgson & Pinchbeck, 2019) due to risk of hemorrhaging. Detailed descriptions of the three techniques, as well as emasculator usage, are summarized with diagrams by Green (2001). There are numerous reviews outlining the process, current techniques, and the associated risks predominantly in horses (Moll et al., 1995; Searle et al., 1999; Green, 2001; Kilcoyne, 2013; Kilcoyne et al., 2013; Robert et al., 2017; Hodgson & Pinchbeck, 2019; Baldwin, 2023; Rodden et al., 2024). Risks in particular will be discussed further in the next section; however, it is important to note that all techniques have some degree of inherent risk.

Some research has examined, through survey, the favoured methods utilized by veterinarians in Australia (Owens et al., 2018a) and the United Kingdom (Price et al., 2005; Kamps et al., 2024). In Australia, Owens et al. (2018a) reported that veterinarians favoured (≥50%) in-field castrations using the open technique. The prevalence of castrations performed in a hospital environment was very low, with Owens et al. (2018a) reporting that only 4% of 134 respondents conducted the majority of their castrations in a surgical theatre. When asked about peri-operative pharmaceutical use, veterinarians reported the use of penicillin and nonsteroidal anti-inflammatory drugs (NSAIDs; predominantly phenylbutazone) with variable amounts and duration of use (only before, once before and once after, or once before and after for 3 to 5 days; Owens et al., 2018a). Of the 115 respondents who answered the questions regarding perioperative protocols, 25% did not use NSAIDs at all (Owens et al., 2018a).

In the United Kingdom, Kamps et al. (2024) reported that veterinarians also favoured in-field and open technique castrations, with an additional preference for standing castrations. While Kamps et al. (2024) did not delve further into the techniques, they did make note of the high practitioner injuries as a result of standing castrations (49.5%; 150/303 of respondents). Much like Owens et al. (2018a), an earlier study by Price et al. (2005) noted a variety of castration techniques (though still favouring standing), drug usage, and post-operative care strategies by veterinarians in the UK. When asked specifically regarding post-operative pain control, 45.4% (128/282 respondents) indicated that they did not provide any analgesia following castration (Price et al., 2005). When analgesia was used, phenylbutazone was once again the most common (Price et al., 2005). More recent surveys, when available, may shed light on whether this percentage is reflective of current practices.

Canadian-specific castration data is lacking with regard to favoured techniques, as well as differences in techniques between veterinarians and lay person practitioners, who are legally permitted to castrate equids in Alberta and Saskatchewan (Veterinary Profession Act, RSA 2000; The Veterinarians Act, 1987). In the most recent scoping review on equine castration conducted by Rodden et al. (2024), only 5 of the 71 eligible studies were experiments conducted on Canadian horses. Regarding a population of Canadian horses specifically, Stover and Caulkett (2021) provide a case study on 10 gentled mustangs castrated in-field in Alberta, with a focus on the intramuscular anesthetic protocol used to safely facilitate a recumbent, closed technique castration. As part of the protocol, lidocaine was utilized prior to surgery, intravenous phenylbutazone was utilized during surgery, and there was no indication that any analgesic was provided post-surgery (Stover & Caulkett, 2021).

2.2 Complications and Risks

Prior to surgery, it is important to conduct a thorough examination to ensure both testicles have descended and are present (Searle et al., 1999), as the castration of horses with undescended or absent testicles requires a more involved surgery. In addition, there are surgical and post-surgical complications that can occur even when operating on a seemingly healthy equid. Rate of complications differs substantially between studies, with the variety of techniques making it challenging to compare them directly.

At the lower end Carmalt et al. (2008) reported complications in 6.9% (9/131) of draft colts undergoing recumbent castration. Furthermore, a retrospective evaluation by Hinton et al. (2019) reported complications in 27 out of 252 horses (10.7%) castrated specifically using a Henderson drill. This was similar to the complication rate (33/324 horses; 10.2%) reported by Kilcoyne et al. (2013) in a retrospective analysis conducted on routine equid castrations at the same facility from 1998 to 2008. Kilcoyne et al. (2013) indicated use of both closed and semi-closed techniques, as well as equids castrated in either the recumbent or standing position. This use of multiple methods was reflected in a retrospective analysis, by Hodgson and Pinchbeck (2018), reporting a complication rate of 11.2% (44/495 castrations).

Higher incidences of complications have been described, ranging from 16% to 29.4%, as indicated in experimental studies and survey self-report (Robert et al., 2017; Racine et al., 2018; Owens et al., 2018b). Finally, Rosanowski et al. (2017) reported the highest complication rate at 60% (150/250) when horses were castrated using a combination of open and standing techniques; however, this was attributed to the authors including mild swelling as a complication (where it had been excluded from other studies). As with inconsistent definitions regarding techniques, Rodden et al. (2024) also noted that the definition of "complication" varies between researchers, sometimes including routine elements of surgery (e.g., minor swelling) while at other times focusing only on the more extreme (e.g., evisceration). This classification of mild symptoms as complications, rather than limiting complications to the most severe symptoms, may affect the reported incidence in other studies as well (e.g., Kummer et al., 2009).

Different complications resulting from castration have been summarized in numerous, predominantly retrospective reviews (Moll et al., 1995; Searle et al., 1999; Green, 2001; Kilcoyne, 2013; Kilcoyne et al., 2013; Robert et al., 2017; Hodgson & Pinchbeck, 2019; Baldwin, 2023; Kilcoyne & Spier, 2021; Rodden et al., 2024) and have been compiled below in Table 2.1. The incidence of each complication, if reported, has been indicated as well.

Table 2.1: Description of surgical and post-surgical complications as a result of castration

Complication	**% Incidence Range**	**% of Instances Reported**
Postoperative swelling, hematoma, and/or seroma (fluid pocket) formation	3.8%–27.6%	27.6% (6400/23,229; Moll et al., 1995) 3.8% (5/131; Carmalt et al., 2008) 24.3%. (58/238; Kummer et al., 2009—includes mild to severe symptoms) 4.9% (16/324; Kilcoyne et al., 2013) 9.4% (15/159; Robert et al., 2017) 5% (2/38; Crosa & Desjardins 2018) 9.7% (38/392; Hodgson & Pinchbeck, 2019)
Infection	3.4%–4.6%	3.43% (796/23,229; Moll et al., 1995) 2.1% (7/324; Kilcoyne et al., 2013) 4.6% (18/392; Hodgson & Pinchbeck, 2019)
Excessive hemorrhage	1.8%–2.4%	2.44% (566/23,229; Moll et al., 1995) 2.3% (3/131; Carmalt et al., 2008) 2.1% (5/238; Kummer et al., 2009) 1.8% (6/324; Kilcoyne et al., 2013)

Lameness	1.17%	1.17% (272/23,229; Moll et al., 1995)
Eventration (portion of the intestines descends and emerges through castration incision; Kilcoyne, 2013)	0.1 %–4.8%	0.2% (47/23,229; Moll et al., 1995) 4.8% (27/568; Shoemaker et al., 2004)* 0.3% (1/324; Kilcoyne et al., 2013) 0.20% (82/41,664; Haffner et al. 2018) 0.1% (5/5100; Owens et al., 2018a) 1% (4/392; Hodgson & Pinchbeck, 2019)
Funiculitis (inflammation of spermatic cord; Searle et al., 1999)	4.4%	4.4% (4/90; Koenig et al., 2019)
Peritonitis (inflammation of the lining of the abdomen)	0.02%	0.02% (5/23,229; Moll et al., 1995)
Hydrocele (fluid accumulation in the tunica vaginalis; Searle et al., 1999)	0.26%	0.26% (61/23,229; Moll et al., 1995)
Penile damage	0.004%	paralysis—0.004% (1/23,229; Moll et al., 1995)
Omental prolapse or hernia (portion of the abdominal lining descends and emerges through castration incision; Carmalt et al., 2008)	0.76%–2.8%	2.8% (16/568; Shoemaker et al., 2004)* 0.76% (1/131; Carmalt et al., 2008) 1.1% (1/90; Koenig et al., 2019)
Pyrexia (fever)	0.6%–21.4%	2.56% (595/23,229; Moll et al., 1995)

		21.4% (51/238; Kummer et al., 2009—includes mild to severe symptoms) 0.6% (2/324; Kilcoyne et al., 2013) 2.5% (4/159; Robert et al., 2017)
Tetanus	Incidence unreported	Incidence unreported
Colic	3.8%–8.8%	8.8% (21/238; Kummer et al., 2009) 3.8% (6/159; Robert et al., 2017)
Retained stallion-like behaviour (>1 year)	20–30%	20–30% (Line et al., 1985)
Anesthetic death	0.02%	0.02% (4/23,229; Moll et al., 1995)**

* *Noted to be unusually high*
** *Noted to be unusually low compared to overall average anesthetic death in horses, which is 1% (Deutsch & Taylor, 2022)*

Reasons cited for complications vary, including breed (Moll et al., 1995; Robert et al., 2017), technique used (Moll et al., 1995; Searle et al., 1999; Kilcoyne et al., 2013), emasculator choice (Moll et al., 1995), horse age (May & Moll, 2002; Robert et al., 2017; Hodgson & Pinchbeck, 2019), tissue trauma (Hunt, 1991), inadequate exercise post-surgery (Hunt, 1991), compromised sterile field (Hunt, 1991; Hodgson & Pinchbeck, 2019), and use of additional anesthesia during surgery (Kilcoyne et al., 2013). Ligature use has also been cited as a cause for complications (Moll et al., 1995), but the lack of identical methodology between studies where ligatures are used make comparisons difficult (Kilcoyne, 2013). The role that surgeon knowledge and experience play regarding complication rates has not yet been explored, but both have been recognized as valuable contributors to complication incidence (Kilcoyne & Spier, 2021). Most complications are considered mild and easily resolvable (Kilcoyne et al., 2013; Kilcoyne & Spier, 2021), with the exception of eventration, hemorrhage, infection, and peritonitis (Kilcoyne, 2013; Kilcoyne et al., 2013). The persistence of stallion-like behaviour (e.g., mounting) for any amount of time after castration is not well documented. In a review by Baldwin (2023), continued unwanted behaviour is simply described as "innate" or attributed to incomplete castration, but current research on the topic is limited.

2.3 Pain Control

Both physiological responses and behavioural response measures via pain scales indicate that castration is painful for equids (e.g., Ashley et al., 2005; Sanz et al., 2009; Dalla Costa et al., 2014; Abass et al., 2018; Trindade et al., 2021). Despite this, there is an overall lack of agreement regarding how painful castration is. Waran et al. (2010) surveyed veterinarians in the United Kingdom, noting that they ranked castration pain between 4/10 and 7/10, with a cohort of 20% ranking it either 1/10 or 10/10. Price et al. (2002) also reported clinicians regard castration pain as low severity. In contrast, when surveying Canadian veterinarians, respondents rated the average pain level of horses experiencing castration without analgesia at 7.4 (95% Confidence Interval, 7.2–7.6), which was higher than a dental extraction (6.2) and a corneal ulcer (6.0) (Hewson et al., 2007). Recognizing pain may also be challenging, as discussed at length in the previous section. Donkeys and mules in particular may be difficult to evaluate, given their stoicism (de Oliveira et al., 2019; McLean et al., 2019).

As a result, the use of analgesics both before and after surgery varies greatly, as self-reported by veterinarians or described in research protocols. Owens et al. (2018a) reported that 25% of Australian survey respondents gave no NSAIDs before surgery and <50% gave NSAIDs after surgery. This limited use of NSAIDs post-surgery was comparable to American practitioners (51%, Moll et al., 1995) and UK practitioners (45%, Price et al., 2005; 39%, Hodgson & Pinchbeck, 2019). In contrast to the response from Owens et al. (2018a) and Price et al. (2005), 95.8% of the 585 Canadian veterinarians surveyed utilized some form of analgesia during equine castration, citing xylazine and ketamine as the two most common choices (Hewson et al., 2007). Xylazine and ketamine are both primarily used as anesthetics, however, and their efficacy as analgesics depends heavily on the type of pain being experienced (Goldberg & Shaffran, 2014). Research methodology often doesn't include mention of post-surgery analgesic unless the focus of the study is on pain control; Kilcoyne et al. (2013), however, reported that only 29 of 324 (9.0%) equids involved in their documented procedure received NSAIDs post-surgery. In contrast, more recently Sellon et al. (2023) reported that 76.7% (112/146) of equine veterinarians in the United States provided a nonsteroidal anti-inflammatory drug (NSAID) at the time of castration, with a comparable number also recommending the provision of an NSAID afterwards as well. Sellon et al. (2023) also noted that newer graduates of veterinary school were more likely to use pain control both during and after castration surgery compared to veterinarians who graduated earlier than 2002.

Research examining analgesia usage post-castration was examined in a scoping review conducted by Rodden et al. (2024) as well as evaluated by a panel of experts at the British Equine Veterinary Association (Bowen et al., 2020). Both Rodden et al. (2024) and Bowen et al. (2020) reported a lack of evidence to strongly support the use of a singular analgesia protocol, indicating the need for a larger body of evidence which includes standardized pain scoring of equids post-castration. Bowen et al. (2020) concluded that the current literature supported the use of a local anesthetic and a systemic analgesic during surgery, which was the recommendation of the British Equine Veterinary Association. Furthermore, despite only indicating "moderate" certainty in the reviewed literature, the panel also recommended that analgesia should be provided for a minimum of 3 days post-surgery (Bowen et al., 2020). Some blinded research has also been conducted regarding the efficacy of meloxicam (NSAID) post-surgery (Olson et al., 2015), as well as the efficacy of buprenorphine (opioid) versus butorphanol (morphine-like) in ponies (Rigotti et al., 2014), local mepivacaine in horses (Abass et al., 2018), and intrafunicular lidocaine in large donkeys (Suriano et al., 2014). Currently, however, there does not appear to be a clear protocol for the most effective analgesic, particularly regarding NSAID usage (Bowen et al., 2020). Further exploration in this topic, particularly as it relates to non-horse equids who respond differently to analgesic (Grosenbaugh et al., 2011), is needed.

Though opinions vary with regards to best practices regarding pain control following castration in equids, the necessity of some form of effective pain control post-surgery is well recognized in other large animals who also undergo castration for husbandry purposes (cattle and pigs; review by Kleinhenz et al., 2021)

2.4 Future Research

1. More research regarding the prevalent techniques and analgesic usage specifically in Canada would be beneficial to determine a baseline for common practice within the country.

2. The role that surgeon knowledge and experience play regarding complication rates has not yet been explored, particularly in relation to complication incidence, and needs further research.

3. The persistence of "stallion-like" behaviour after castration has not been well documented and needs to be studied further.

4. Research is needed to determine the ideal analgesic protocol for castration, as well as the timing, duration and dosage of a provided analgesic needed to maximize welfare post-surgery.

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3 Principles in Training and Learning Theory

CONCLUSIONS

1. **Experimental evidence demonstrates that horses are capable of learning and remembering a variety of tasks. Successful learning and performance of these tasks can be dependent on a variety of factors, such as sex, breed, motivation, stress, and the type of reinforcement used.**

2. **Training equids in a way that aligns with their physical and mental capabilities is a key component of good equine welfare. Consistent and appropriate use of learning theory concepts is necessary to promote positive, safe outcomes for equids and trainers and reduce unwanted behaviours.**

3. **Equestrians struggle to define learning theory concepts, even when presented with case scenarios.**

Correctly interpreting behaviour is a vital component of ensuring horses lead a good life (Hall & Kay, 2024). Over the past two decades, there has been a growing body of research examining human–horse interactions, specifically in training, handling, and riding, under the umbrella term "equitation science" (McGreevy, 2007). By developing a more rigorous way to evaluate the human–horse interaction during these periods of contact, equitation science seeks not only to understand the horse's cognitive abilities, but also to foster a positive way of being with horses that supports their well-being, improves their performance, and reduces risk for human handlers (Starling et al., 2016). In recent years, the work published by equitation scientists has been utilized to inform practice and changes to policy in support of better equine welfare (Randle & Waran, 2017). It is through this body of work that equitation scientists have been able to better understand how horses learn, what motivates them to learn, what external factors play a role in learning, and how unintentionally poor or inconsistent training techniques lead to undesirable outcomes. From the human point of view, there is also research seeking to document how well trainers, veterinarians, and handlers understand the underlying principles of how animals learn, with the goal of further improving both the understanding of equine learning theory and its application in human–horse interactions.

3.1 Understanding How Equids Learn

It is important, first, to understand the way in which horses and other equids learn. A review by McBride et al. (2017) describes the underlying neurophysiology of the horse. In brief, McBride et al. (2017) describe the role of dopamine in the shaping of behaviour, both through positive (e.g., when given a reward) and negative (e.g., when successfully escaping an unpleasant stimulus) reinforcement, outlining the chemical processes that underpin learning. Simplified, and in brief, dopamine acts as the chemical "gauge" as to whether an activity should be conducted again, supporting reward-seeking and aversive-avoiding behaviour through increased or decreased production respectively (Lopez & Lerner, 2025). It is through these processes that the underlying principles can be better understood, such as the threshold at which a horse will no longer work for a nonessential food item, or the point at which a negative reinforcer (e.g., leg pressure) becomes a punishment (e.g., severely increased leg pressure without reprieve when desired behaviour is given), creating conflicting cues (McBride et al., 2017). Numerous cognitive and behavioural tests have been conducted on horses to determine their capabilities, including extinction learning exercises (the use of a food reward to teach a task, followed by the removal of the food reward during subsequent trials; e.g., Hemmings et al., 2007) and judgement bias (animals are trained to recognize one positive and one negative stimuli, and then are presented with an ambiguous stimulus that is neither; e.g., Freymond et al., 2014). Roberts et al. (2017) were also able to successfully validate a portable, fully automated system (i.e., a system that requires no direct human contact or cueing) to test for cognitive function, which may help in standardizing such tests moving forward as well as removing handler influence. In this system, horses were trained to correctly select a white screen (all others were black) in response to an auditory cue (Roberts et al., 2017). Overall, however, there is plentiful evidence to support that horses are capable learners and can perform tasks both aligned and unaligned with their natural behaviours.

3.1.1 Memory

A key component of successful learning is memory; that is to say, the retention of the skill or what was learned. It is worth noting, however, that test design appears to play a significant role in the outcomes of memory-related research. To that end, conflicting research has emerged regarding the short-term and long-term memory capabilities of horses. McLean (2004) found that, after a delay of 10 seconds, horses could not correctly locate a hidden food item, while Murphy (2009) reported that horses were able to locate a food item after a 12-second delay at a rate higher than chance. When incorporating an obstacle into the same task (referred to as a "detour problem"), Baragli et al. (2011b) also found that horses were able to correctly locate the hidden object even after 10- or 20-second delays. Like Baragli et al. (2011b) and Murphy (2009), Hanggi (2010) also had success testing horses following delays of up to 30 seconds, this time when conducting a two-choice test where horses had to locate food placed in 1 of 2 buckets.

Long-term memory studies are more challenging to conduct, and the results have been similarly divided. In a study by Gabor and Gerken (2018), 3 ponies were successfully taught a task and then left alone for 1 year before being retested. While no pony could successfully complete the discrimination task they were taught (discriminate different quantities of geometrical symbols, e.g., 3 versus 2), all ponies could perform the steps necessary to complete the test (i.e. willingly stepping into the test box, waiting for the cue to answer the test question, and backing out when completed) without any prompting (Gabor & Gerken, 2018). Gabor and Gerken (2018) concluded that different tasks were retained differently, if at all, and that the retention may have had some basis in which tasks were more "valuable." In other long-term memory experiments, horses demonstrated the ability to recall the correct path in a maze after both 1 week and 2 months (Marinier & Alexander, 1994), could remember how to open a wooden chest for a food reward after 4 weeks (Le Scolan et al., 1997; Wolff & Hausberger, 1996), could remember a task they'd been trained to do (walk over a tarpaulin) 1 year later (Heleski & Bello, 2010), and could perfectly perform both tasks taught to them after a period of 22 months (tasks were to move backwards on command and cross an obstacle after a bell was rung to avoid a negative stimulus; Valenchon et al., 2013a).

Several researchers have also examined cognition and memory in donkeys and mules. In hidden object tests lasting 90 seconds and barrier tests using a food reward, McLean et al. (2024) were able to demonstrate that miniature donkeys were able to perform these tests at the same level as horses. Baragli et al. (2011a) and Osthaus et al. (2013) also used variations of the detour tests where donkeys or mules were required to reach a target around an obstacle or, in the case of Baragli et al. (2011a), remember the location of a hidden object. Donkeys were able to retain, after 30 seconds, the location of an object even when it was hidden from view (Baragli et al., 2011a). When navigating around barriers, Osthaus et al. (2013) were able to demonstrate that mules were significantly faster than both donkeys and horses. Mules have also been shown to be significantly better at a visual learning task (stimulus discrimination) when tested against donkeys and horses (Proops et al., 2009). More research is necessary in this area to better understand the capabilities of both donkeys and mules.

3.1.2 Factors Influencing Learning

There are a great number of factors that may affect a horse's ability to learn or the success of any learning exercise, including sex, breed, social status, and genetic factors (Brubaker & Udell, 2016). Temperament in particular has seen a renewed interest over the last decade, with multiple researchers attempting to create a personality scoring system to better categorize horses for the purposes of specific research questions or for breeding (e.g., Lansade et al., 2016; Suwała et al., 2015; Lee & Yoon, 2019; Rankins & Wickens, 2020). While there is no singular personality system that has been created (Rankins & Wickens, 2020), Lansade et al. (2016) focused on the dimensions of fearfulness and tactile sensitivity, noting that horses with higher fearfulness and lower tactile sensitivity were more difficult to ride, but performed better in competitions. Calviello et al. (2016) also focused on measuring reactivity in horses as a facet of temperament, noting that it was what most strongly affected how horses and humans interacted, particularly during training. Reactivity here was measured using a composite score of behaviours (movement, position of ears and eyes, breathing, urination) and reactions of animals to a forced approach test by an unfamiliar handler (Calveillo et al., 2016).

With respect to specific conditions or situations that could enhance or inhibit learning, Olczak et al. (2016) highlighted both motivation and stress as the two biggest contributing factors. Olczak (2021) reported that horses are demonstrably motivated by food, but that this motivation alone was not enough to affect the outcome of both learning and fear tests. Hall and Kay (2024) also discouraged any training practice that restricted movement, citing it as not only unnecessary but also contributing to the masking of feedback behaviours to the handler and contributing to aversive, and possibly painful, experiences for the horse. Separation, too, goes against a horse's natural instincts as a herd animal, though limited research has been conducted regarding the effects of the presence of a companion horse during training. Hartmann et al. (2011) noted that there was no difference when comparing the training efficiency of mares taught a task with a companion versus without, but that horses with a companion showed a significant decrease in heart rate. Christensen et al. (2008) and Rørvang et al. (2018) also supported the use of habituated horses in teaching naive horses how to habituate to frightening stimuli (including foals; Christensen, 2016). Further exploration in this area is needed.

3.1.3 Test Design

Beyond the horse's innate capabilities or external stimuli, test design plays a crucial part in the results of any learning experiment. A horse's physical capabilities, particularly their vision, has resulted in significantly different test outcomes simply when changing the location of the objects utilized (Brubaker & Udell, 2016). With respect to cueing, alongside food rewards horses and ponies both respond successfully to visual and auditory cues from human handlers when being directed to select the correct bucket in a choice test (Prendergast et al., 2016). Lovrovich et al. (2015) also found that horses seemed to be capable of making situational decisions regarding whether to rely on handler-related cues or not when asked to perform a similar task. In this experiment, horses were tasked with locating a carrot hidden under a bucket they had or hadn't seen a handler hide (Lovorich et al., 2015). In subsequent trials when no horses saw where the carrot was hidden, horses who were part of the group that had previously seen a handler hide a carrot initially were more likely to choose buckets nearest the handler to start, and then adjusted their guessing to be identical to the group that had never seen the handler hide the carrot when that didn't increase their odds of success (Lovrovich et al., 2015). A review of cognitive capabilities of horses by Brubaker and Udell (2016) noted that equids were capable of recognising individual people, reacted differently to familiar versus unfamiliar handlers, and could determine if handlers were looking at them versus being inattentive. Horses also have demonstrated some degree of social learning from conspecifics, but the results are varied and appear to be highly task-dependent (Nicol, 2002; Murphy & Arkins, 2007; Brubaker & Udell, 2016; McVey et al., 2018). As indicated in the review of social learning in horses by Rørvang et al. (2018), horses demonstrate behaviours indicative of social transmission rather than social learning, whereby having a conspecific increases the motivation of a horse to behave in the same way (e.g., interact with an object that a herd member is already interacting with).

Additionally, the type of reinforcement used in a test (positive or negative) can produce different results, and success utilizing one type of reinforcement to teach a task does not always result in the same success if the other type is used instead (Visser et al., 2003; Ahrendt et al., 2015). Visser et al. (2003) specifically noted that different horses responded better to different types of reinforcement, suggesting a measure of individuality regarding preferences. This view was also supported in the review by Murphy and Arkins (2007) and the subsequent commentary by Heitor and Vicente (2007), who cautioned against generalizing the abilities of a species based on a few individuals. It is important to also mention that the majority of equine learning research is conducted using positive reinforcement, using rewards to teach horses to perform a variety of tasks (e.g., Baragli et al., 2011b; Christensen et al., 2012; Valenchon et al., 2013b), a style which is at odds with the way that horses are predominantly trained within the industry (McGreevy & McLean, 2010).

3.2 Training Equids: The Human Element

A great deal of human–horse interaction occurs during training, where a human handler or rider is actively working with a horse to alter or reinforce behaviour. Training is defined as "the intentional modification of the frequency and/or intensity of specific behavioural responses" (Goodwin et al., 2009). For the purposes of this chapter, it is used to mean the modification of behaviour and does not encompass the act of exercising horses to increase physical condition. Ultimately, the goal of any kind of behavioural training, be it ridden or otherwise, is control (Doherty, 2025). The manner with which horses are trained is extremely important. Handlers and trainers have an ethical obligation to train horses in a way that aligns with equine cognitive abilities whilst also being effective at achieving the desired outcome with minimal stress to the animal. This is important not only from an animal welfare perspective, but also with regard to human safety. Poorly trained horses who have developed bad behaviours contribute significantly to wastage (Carroll et al., 2023) and injuries to professionals who regularly are required to provide potentially aversive care (e.g., vaccinations by veterinarians; Doherty et al., 2017).

Beyond this, the training of horses contributes significantly to the perception of the equestrian sport, of which poor perception negatively affects social license. In simple terms, people do not want to see the perpetuation of training methods that they perceive as being harmful or aversive for the horse (Bartlett et al., 2024b). Luke et al. (2024) also noted that there has been a decline in the credibility of the industry, wherein there is a growing lack of trust that the industry is doing “what is best for the horse” with welfare as the highest priority (Jijelava & Vanclay, 2017; Prno & Slocombe, 2012; Douglas et al., 2022; Luke et al., 2024). The ramifications this may have on the industry as a whole, including its equid members, is yet to be seen. Regardless, it adds additional complexity to the conversation, particularly as it relates to the human element in the horse–human pair. Luke et al. (2024) also noted that horse owners prioritize meeting their equestrian-related goals and are strongly motivated by competition and a return on their financial investment. Beliefs also affect training approaches, as demonstrated by Bartlett et al. (2024b), who found that owners who believed horses could feel pain were less likely to report using aversive-based techniques. Additionally, owners who believed that horses could intentionally misbehave were more likely to use aversive-based techniques (Bartlett et al., 2024b). Acknowledging these motivators is invaluable in understanding the external factors at play and how they affect the way horses are handled and trained.

3.3 Training Equids: The Horse

At the most basic level, handling and training of horses requires them to work against many of their natural instincts (e.g., in solitude, in the presence of fearful stimuli), to communicate with a non-equids (humans), and to potentially be trained and retrained in a variety of disciplines throughout the horse’s lifetime (Brubaker & Udell, 2016. While the full ramifications of these remain unclear (McGreevy et al., 2009; Brubaker & Udell, 2016), they are worth considering when evaluating training approaches and their potential short- and long-term effects on horse welfare.

Very recently, there have been two comprehensive reviews of the current training literature by Bartlett et al. (2024a) and Doherty (2025), including thoroughly explained terminology. Doherty (2025) provided a history and explanation of both historical and more modern training approaches, as well as an explanation of learning theory, through the lens of how such methods would be useful to veterinarians and their equine patients. Bartlett et al. (2024a) conducted a literature review of published research focused on equine training to identify the most common approaches, their associated terminology, and any inconsistencies within the descriptions of each method. They emphasized the need for clear, concise, and methodologically repeatable training approaches to increase the credibility of their results (Bartlett et al., 2024a). Overall, Bartlett et al. (2024a) reported that the language discussing training methods was clearest for those based in operant and classical conditioning, and that language became more “grey” and subjective in other approaches (e.g., “natural” horsemanship). Methodological details were often also very vague, which made replication of training approach studies difficult (Bartlett et al., 2024a).

Despite this, Bartlett et al. (2024a) were able to divide training approaches into 10 categories: positive reinforcement, negative reinforcement, positive punishment, combined reinforcement (both positive and negative reinforcement), avoidance learning (combined positive punishment and negative reinforcement), habituation, conspecific (techniques relying heavily on human–horse interaction through the use of horse-like body language; e.g., “join up,” “natural horsemanship”), conventional training, imprinting, and a specific method named “T-touch equine awareness,” which involved negative reinforcement and body work. Using these divisions, research in these different categories will be examined in this report, with the exception of conventional training and T-touch, as neither category had consistent methodology. Bartlett et al. (2024a) did note, however, that the majority of the training research conducted is reflective of the scientific community and its current perceptions and methodology; the methods used may not be, as of yet, reflective of the current way horses are handled and trained beyond experimental design. To that end, researchers such as Fenner et al. (2020) have begun to develop a standardized questionnaire for the training, management practices, and behaviour of horses in their home environment not only to map the way practices change over time but also to determine what constitutes normal behaviour in a more real-world scenario.

3.3.1 Reinforcement

Positive reinforcement is defined as “the addition of pleasant stimuli after a behaviour is performed to increase the likelihood that it is repeated” and is the most prevalent training approach in literature (Bartlett et al., 2024a). The most common reinforcer used is food (n=41 studies, 97.6%), but tactile reinforcement (e.g., petting or scratching) was also used in studies reviewed by Bartlett et al. (2024a). The importance of food as a valuable reward has been demonstrated by Williams et al. (2004), who found that there was no difference between horses trained using only food rewards versus those who were trained using a clicker and a food reward. In contrast, soothing voice cues (Heleski et al., 2015) and the use of only the word “good” as a reward after it had been associated with a food reward (Lansade & Calandreu, 2018) were not enough to significantly improve the horses’ ability to perform during experimental trials. Food rewards were also successful in teaching donkeys an operant task (push a button) in just 4 sessions (Seganfreddo et al., 2022). Positive reinforcement is accepted as a successful method of training for horses, but it is frequently criticized for its potential lack of application outside of quiet, controlled environments where there may be more competing interests or considerable distractions, such as other horses or frightening stimuli (Doherty, 2025). The use of positive reinforcement also can also turn anticipation (of a food reward) into frustration if the reward is delayed or unable to be accessed (Ricci-Bonot & Mills, 2023; Phelipon et al., 2024). Of additional note, positive reinforcement research is not generally conducted on behaviours related to riding (Bartlett et al., 2024), which is an area of further research that would benefit this particular training approach.

Negative reinforcement is defined as “removal of aversive stimuli after a behaviour is performed to increase the likelihood that it is repeated” (Bartlett et al., 2024a). This type of training represents the majority of training within the equine industry (Ahrendt et al., 2015), with the use of pressure as the most common aversive stimuli (Bartlett et al., 2024a). In comparison to positive reinforcement, 25% (5/20) of studies that utilized negative reinforcement focused on behaviours related to riding (Bartlett et al., 2024a). The responsiveness of horses to negative reinforcement is likely the reason for its prevalence and success in training. Eisersiö et al. (2021), for example, conducted rein tension trials on 20 Warmblood horses and reported that the rein tension could be reduced by half in just 8 trials to achieve the same result. Similarly, Ahrendt et al. (2015) conducted a standardized test to evaluate learning as a result of negative reinforcement, measuring the amount of force required to get the desired result (e.g., walk sideways), the change in that force value over time, and the number of trials needed to see the change. Horses were able to learn the task after a single day, and there was a significant decrease in the amount of force required (Ahrendt et al., 2015). This effect plateaued between days 2 and 3, however, and horses could not transfer tasks between left and right sides (Ahrendt et al., 2015). The choice of desired behaviour also appears to be important when utilizing negative reinforcement. Medeiros et al. (2020) reported that negative reinforcement training was most effective for task-related behaviours (e.g., leading, back off, move away from whip), whereas an association (e.g., a vocal cue) plus either negative reinforcement or punishment did not result in behaviour change for lunging or bite inhibition.

3.3.2 Punishment

Negative punishment specifically is the act of "withholding something attractive such as food" (McGreevy & McLean, 2010) to reduce the likelihood of that behaviour being repeated and is typically not utilized directly in research settings (Bartlett et al., 2024a). In contrast, positive punishment is the "addition of aversive stimuli after a behaviour is performed to reduce the likelihood that it is repeated" (Bartlett et al., 2024a). Bartlett et al. (2024a) reported only one published paper that specifically indicated that positive punishment was utilized. Punishment, when utilized appropriately, is a potent inhibitor of behaviour (Dworetzky, 1994); however, the use of punishment hinges on the timing for the horse to correctly associate the previous action with the punishment (Mills, 1998; Hockenhull & Creighton, 2013). Punishment that is too intense, poorly-timed, utilized too frequently, or utilized indiscriminately has been shown to have limited effectiveness and potentially cause habituation or learned helplessness (Mills & Nankervis, 1999; McGreevy, 2004). Additionally, positive punishment in particular can very easily become abuse when used inappropriately and violently (Mills & Nankervis, 1999; McGreevy & McLean, 2010). The goal of punishment is to extinguish the behaviour; if the behaviour persists, the action utilized to stop it is no longer considered a punishment (Foster, 2025).

3.3.3 Combined Approaches

The combined reinforcement approach utilizes both positive and negative reinforcement, whereby an aversive stimulus is applied and when the animal gives the desired response, they are given an additional reward in the form of food (Bartlett et al., 2024a). Bartlett et al. (2024a) once again highlighted the difficulty of providing positive reinforcement during riding-related activities, noting that the one study that provided positive reinforcement while training for a halt did so using a "telemetrically operated reward device" to provide molasses water (Warren-Smith & McGreevy, 2007). Another combination approach was titled "avoidance learning" and referred to the use of both positive punishment and negative reinforcement to achieve a desired outcome (Bartlett et al., 2024a). Bartlett et al. (2024a) describes this approach as the one most closely resembling the way in which horses are currently trained. For instance, when a horse is asked to move forward with leg pressure, this aversive stimulus is augmented by a positive punishment (e.g., a tap with a whip) and stronger leg pressure until the horse responds appropriately, at which point the leg pressure is released (negative reinforcement). Both of these mixed method training approaches are relatively uncommon in research. Heleski and Bello (2010), however, did report that when evaluating horses who had been trained to walk over a tarpaulin 1 year prior, those who had been trained using a combined negative and positive reinforcement approach were able to complete the task and reach the experimentally decided "ideal calmness levels" faster than horses that had only been trained using negative reinforcement.

3.3.4 Conspecifics

The conspecific category is perhaps the most diverse methodologically, as it covers a range of techniques that claim to have basis in behaviours exhibited by horses towards other horses (Bartlett et al., 2024a). These approaches include methods such as "round pen technique," "join up," and "natural horsemanship," and represent a wide spectrum of approaches that tend to utilize flooding (preventing horses from escaping fearful stimuli), shaping (reinforcing stages of a desired behaviour), response prevention (e.g., stopping a horse from moving away from an unpleasant stimulus), habituation, negative reinforcement, and positive punishment when the learning principles can be identified at all (Bartlett et al., 2024a; Doherty, 2025). The claims made by practitioners of these training approaches regarding speaking "horse's language" have been challenged, particularly given the emphasis many methods place on the concept of dominance (Doherty, 2025). Indeed, Henshall and McGreevy (2014) reported in their review of round pen training styles that there was an overemphasis on agonistic behaviours and an underemphasis on affiliative interactions, something in direct opposition of natural horse behaviours. Furthermore, a review of dominance and leadership in horses by Hartmann et al. (2017) concluded that it was "unlikely that horse–horse social status translates to analogues of human–horse interactions, and the concept of leadership as advocated in many training manuals proves to be unreliable in the horse…" The results of the conspecific approach are therefore more likely attributed to reinforcement of a desired outcome through consistent reward than anything related to perceived dominance (Hartmann et al., 2017). Fenner et al. (2019) also stressed the importance of not pushing horses above safe thresholds of arousal, which invoking a flight response during round pen training has the potential to do. Horses experiencing high arousal have a much greater chance of displaying defensive behaviours, and high arousal states are known to compromise learning (Fenner et al., 2019). Ultimately, however, the utilization of trainer-specific styles makes comparisons of these techniques difficult (Bartlett et al., 2024a).

3.3.5 Habituation and Imprinting

Habituation is the "repeated exposure to stimuli that do not result in any reinforcement or punishment, resulting in a decreased response to the stimulus" and is difficult to isolate in training research as many trainers may utilize this approach without indicating it in the methodology (Bartlett et al., 2024a). Despite this, habituation has been shown to be successful to help horses cope with or adjust to frightening circumstances most effectively through desensitization (Christensen et al., 2006), with notable success in reducing fear during loading (Yngvesson et al., 2016). Finally, imprint training describes "exposing foals to a range of different stimuli and handling techniques shortly after they are born" (Bartlett et al., 2024a). The results of imprint training are mixed, with some studies supporting lower reactivity (Simpson, 2002; Spier et al., 2004), while others report no long-lasting positive handling effects and potential for long-lasting harmful effects due to flooding (Williams et al., 2002, 2003). The results of early handling also differ between equid species, as reviewed by McLean et al. (2019).

3.3.6 Welfare-Compromising Techniques

While the improper use of any technique has potential for threatening equine welfare, the literature specifically highlighting "negative" training approaches is considerably rare. In 2010, McLean and McGreevy published a review of horse techniques that specifically pose a risk to equine welfare, which included, but was not limited to, utilizing 1 signal for 2 or more different responses; simultaneous and contradictory signals; apparatuses intended to increase control or alter the horse's head, neck position, or force the mouth closed; and water deprivation for the purposes of training. Specific training techniques, such as extreme control of the neck resulting in hyperflexion or "rollkur" have also received considerable attention and scrutiny (McLean & McGreevy, 2010).

As mentioned previously, equestrians are highly motivated by competition-related goals (Luke et al., 2024). Training methods that compromise welfare may be normalized if they help achieve that goal, and thus the standards of performance are worth examining to determine if they are attainable without compromising horse welfare. Hawson et al. (2010) examined the idea of "submission," for example, as scorable in dressage, and what submission was meant to reflect with respect to welfare and the mindset of the horse. While on paper, the definition was intended to be positive, De Cartier d'Yves and Ödberg (2005) found that experienced judges were not able to identify "lightness" (i.e., low tension on the reins to the bit in the horse's mouth), and that the parameters for qualities such as "submission" were based on unclear, anthropomorphic definitions that could not be reliably evaluated.

3.4 Undesirable Behaviours

The creation of "bad" or undesirable behaviours through poor training puts horses at considerable risk for rehoming and euthanasia, increasing horse wastage (Carroll et al., 2023). While not all undesirable behaviours are the result of poor training, Caroll et al. (2023) notes that a significant portion are a result of punishment and improper use of negative reinforcement, also citing fear, frustration, and confusion. Doherty (2025) also notes that unwanted behaviours are frequently accidentally reinforced, further adding to undesirable training outcomes and frustration in both horse and trainer. The prevalence of undesirable behaviours in horses, and their negative perception by those who are required to handle them, cannot be overstated, particularly as it relates to their behaviour towards veterinarians. In a survey of equine veterinarians, Pearson et al. (2021) reported that 95% of veterinarians indicated they worked with a "difficult horse" on a monthly basis. These difficult horses resulted in over 80% of the surveyed veterinarians having sustained at least 1 horse-related injury in the last 5 years (Pearson et al., 2021). Management of these unwanted behaviours was also reported to be primarily physical or chemical restraint (Pearson et al., 2021), which has the potential to further negatively impact equine welfare and cause life-long negative associations with veterinarians or veterinary procedures (Doherty, 2025).

Alternatives to physical or chemical restraint are often more time consuming but may help to prevent further escalation of unwanted behaviours, particularly in the presence of veterinarians. In her review on the topic of horse training, Doherty (2025) also highlights habituation (Pearson, 2015b), systematic desensitization, counter-conditioning (Droguett et al., 2024), approach conditioning (frightening object removed when the horse approaches it), overshadowing (presenting two stimuli at the same time so one overshadows the other), response prevention, shaping (breaking down behaviour change into smaller steps; Pearson, 2015b), and positive and negative reinforcement (Pearson, 2015a) as training methods to assist in dealing with “problem” behaviour and encourage safe and welfare-friendly handling for veterinary procedures. Descriptions of these approaches are also described at length by McLean and Christensen (2017). Many of these methods share similar approaches, whereby the horse is slowly introduced to fear-inducing or aversive stimuli while remaining in a calm state. These methods are also utilized in tandem (e.g., exposing a horse to the sound of clippers and utilizing a food reward to encourage standing still in the presence of the sound.) In more laymen-friendly terms, Payne et al. (2015) also describes seven approaches to equid and canine handling that help minimize stress and thereby also decrease potential risk for veterinarians. These seven approaches are consistency of behaviour, understanding previous learning history, use of positive reinforcement, minimizing the aversive, minimizing threat, maintaining the horse’s attention, and use of affiliative behaviour (Payne et al., 2015). Alongside veterinarians, farriers also play a significant role in the handling of horses for procedures that may or may not be aversive; however, currently literature is lacking in the potential benefits of utilizing similar stress-reducing handling techniques.

3.5 Understanding Learning Theory: The Human Side

Beyond scientific research, the uptake of learning theory by equestrians has been considerably more challenging, in part due to difficulty understanding the definitions of each of the four quadrants (positive and negative reinforcement, positive and negative punishment). Positive and negative reinforcement in particular are described as being “poorly understood and poorly applied” (Carroll et al., 2023), which has serious ramifications for training outcomes. Multiple researchers have surveyed different groups of equestrians to determine how well they understood learning theory concepts, as well as if they could correctly identify those concepts in empirical situations. In a survey conducted by Bornmann et al. (2016) of over 1,000 equestrians, 95.82% claimed they understood how horses learned. Despite this claim, a significant number of individuals confused negative reinforcement for positive reinforcement and couldn’t explain how negative reinforcement changed behaviour (Bornmann et al., 2016). Brown and Connor (2017) also surveyed equestrians from the United Kingdom with an average of 12.4 years experience in the industry and found that only a little over 30% of those who considered themselves professionals could correctly define positive punishment and negative reinforcement. These values were similar to those reported by Telatin et al. (2016), who reported that only 34% of respondents (n=376) could correctly define negative reinforcement. Additionally, only 41% could correctly describe how to use the whip and only 39% could describe how to use the leg for appropriate negative reinforcement. Rankins et al. (2025) also reported that adaptative and therapeutic riding instructors struggled similarly with learning theory terminology.

Luke et al. (2023) found that rider knowledge of learning theory was not significantly related to improved horse welfare or rider safety, but this may be due to the relative inability of equestrians to define the concepts. From a colloquial standpoint, the use of words like “negative” and “punishment” create very specific images, and if the terminology is misunderstood it runs the risk of being misapplied (Brown & Connor, 2017). McLean (2005) and McLean and Christensen (2017) both emphasize the potential for confusion when using learning theory language outside the scientific realm, especially if the public assumption is that everything prefaced with the word "negative" represents something unpleasant or "bad" for the horse. Nonetheless, understanding the underlying principles, particularly how to correctly apply punishment and reinforcement, is imperative for riders and coaches alike, as they are principles they apply during every training session, knowingly or not.

3.6 Future Research

1. Further exploration is needed into the factors that affect an equid's ability or willingness to learn. A better understanding of temperament (specifically reactivity), motivation, and the potential effects of conspecifics would help support evidence-based training program recommendations.
2. Retraining horses into new disciplines and potential ramifications for equine welfare is currently understudied and would benefit from further research.
3. Equitation science literature is dominated by research that focuses on horses. More research is needed to determine if other equids learn differently or would benefit from different training approaches.
4. Current literature is lacking on the use of learning theory approaches to assist farrier handling.

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4 Young Horse Skeletal Development and Response to Exercise

CONCLUSIONS

1. **Young horses experience a period of rapid skeletal growth from birth until (on average) they are twenty-four months old, during which a significant portion of mature height is reached. Though skeletal growth and maturity vary considerably by breed, it is during this growth period that the musculoskeletal system is the most responsive to external stressors, such as exercise.**

2. **Exercise above and beyond pasture turnout for foals has been demonstrated to improve bone modelling and remodelling in young horses prior to skeletal maturity. Early practice of sport activities, such as jumping, can help horses under two years of age improve balance, coordination, and technique. There is, however, no current ideal training regimen for young horses.**

3. **Horses at any age that are not properly prepared for the athletic demands of their sport are at risk for musculoskeletal injury.**

4. **Confinement and overwork both result in negative impacts on the musculoskeletal system.**

4.1 Skeletal Development

The appropriate age for a young horse to begin work is a topic of considerable debate, particularly in response to concerns about musculoskeletal injuries. To answer the question of when it is appropriate, it is important to first look at the natural growth of the musculoskeletal system. Growth here is marked by longitudinal changes to the long bones; an increase in height at the withers and both body and back length; and an overall increase in body mass, with maturity represented by a cessation of bone growth (e.g., cervical vertebrae), the closure of growth plates (cartilage at the end of bones responsible for growth) within the limbs, and bone ossification (Rogers et al., 2021).

In a comparative examination of the human stages of skeletal growth with those of the horse, Rogers et al. (2021) describes the stages as rapid infant growth, childhood, puberty and post-pubertal growth spurt, and maturity. In humans, this process spans from birth to approximately eighteen years of age; for the horse, this same path of skeletal development spans from birth until twenty-four months of age, or approximately two years. Though Rogers et al. (2021) generalizes this pattern to all horses, the majority of the research in this area has been conducted on Thoroughbreds, which may not be entirely reflective of other horse breeds.

The timeline for the complete fusion of all bones within the horse's body varies greatly as the axial skeleton may take as long as 5.5 years for the sacral segments to close and between 7 to 15 years for the cranial thoracic spinous processes (Haussler, 1999; Rogers et al., 2021). Many of the investigations into growth plate closure has focused on the distal radius of Thoroughbreds and Standardbreds (Banks et al., 1969; Koskinen & Katila, 1997; Uhlhorn et al., 2000). Studies of the appendicular skeleton have found that distal radius growth plates close between 20 to 31 months of age, with some breeds such as Icelandic horses averaging 27.4 to 32.0 months. There can be a large variability in closure times of the distal radius growth plate even among horses of the same breed (Strand et al., 2007). While much of the scientific research of growth plate closure times has focused on the radius, studies have also shown that growth plates in the distal limb close earlier: the proximal second phalanx (8.08–8.09 months), the proximal first phalanx (7.9–13.6 months), the distal third metacarpal (9.0–13.6 months), and the distal third metatarsal (8.2–14.4 months; Rogers et al., 2021).

Foals also spend a great deal less time in the early stages compared to humans, as shortly after birth a foal must be capable of standing and traveling with their mothers, having been recorded traveling 10 km/day at as young as 9 days old (Rogers et al., 2012). This amounts to a growth period whereby the foal's tendons, cartilage, and muscular tissues are the most sensitive to external stress (for example, exercise) that will shape and prepare them for adult activity (Rogers et al., 2012, 2020). The different elements of the musculoskeletal system have different capacities to respond to external stimuli; however, skeletal muscle, for example, is extremely reactive to exercise, while tendons are much less reactive and much less likely to change significantly (Rogers et al., 2020), a property that causes tendons to become even less reactive with increasing horse age (Smith et al., 2010). Additionally, growth does not occur linearly over this period. LaVigne et al. (2015) measured the change in muscle growth and body mass of a group of young horses (yearlings to four year olds) and determined that there was significantly more growth during the warmer months (from spring to fall) than the colder ones (fall to the following spring), even when horses were fed to maintain the same body condition during both periods. Muscle growth and body mass were measured utilizing ultrasounds of the lateral–medial area between the 13th and 14th rib, body condition score, scale weight, and muscle biopsy. LaVigne et al. (2015) suggest that environmental factors that affect energy expenditure are therefore the most critical to growth.

4.2 Exercise

Alongside nutrient availability, a secondary factor that influences energy expenditure is exercise, which encompasses more than training. Locomotor play in foals, for example, has been shown to have positive effects on the skeleton, particularly on the long bones, and cartilage health (Roberts et al., 2012). From an evolutionary standpoint, this type of play—specifically cantering and galloping (Brama et al., 2002; Kurvers et al., 2006)—allows the foal's musculoskeletal system to be "primed" for future activity during the foal's lifetime (Roberts et al., 2020). If a foal may be headed for an athletically demanding career, it has been suggested the foals be pastured in a manner that encourages this early priming, particularly of their cartilage, to higher exercise levels (Brama et al., 2001; Brommer et al., 2003; Rogers et al., 2007; Roberts et al., 2020). The speed at which a young horse moves as well as the weight carried also play a part in their development. Two-year-old Arabian horses undergoing endurance training (regular exercise focused on longer distances at a slower pace) were compared against a control group that was pastured (undergoing no training), and no difference was found between the groups with respect to bone mineral content (Spooner et al., 2008). Nielsen (2023) suggested that this highlighted the importance of movement at high speeds with respect to the development of bone. With respect to weight, a group of young horses carrying increasing weights (versus the control of no weights) exercised on a horse walker over the course of 78 days showed significantly increased bone mineral content when compared to their control counterparts (Nielsen et al., 2002). It has also been demonstrated in calves that bone change may become uneven as a result of movement in only one direction (e.g., lunging; Nielsen, 2023), though more work is needed to document this effect in horses.

The effects of exercise above and beyond that which can occur for foals on pasture has also been studied in racehorses (primarily Thoroughbreds). Early training in Thoroughbred foals did not cause measurable negative affects to cartilage (Nugent et al., 2004; Dykgraaf et al., 2008; van Weeren et al., 2008), bone (Dykgraaf et al., 2008), or tendons (Moffat et al., 2008) when compared to control groups who were not trained. Firth et al. (2011) also examined the bone development of 32 foals from birth to eighteen months raised with either pasture-only exercise or imposed exercise and pasture exercise, reporting increased bone growth of the third metacarpal (MC III) for the exercised group. The third metacarpal is of particular interest, as it is the place where most of the weight is carried (Logan & Nielsen, 2021). Research in the area of bone strengthening has been conducted on calves: Logan et al. (2019) reported that sprints of 71 metres at least 1 day a week made it 23% more difficult to fracture (post-slaughter) the third and fourth metacarpal of young Holstein calves than the same bones in a group that had been confined. For horses in particular who will move on to a very athletically demanding job, as is the case for young racehorses, increased bone strength at the third metacarpal may be critical to their longevity and decreasing the risk of injury. In horses, Hiney et al. (2004) kept 2 groups of weanling horses in stalls, sprinting one group 82 metres a day for 5 days a week over 8 weeks, and when examining bone mineral content and dimensions, found an increase in both for confined weanlings who had been sprinted. In a similar vein, following 19 of the imposed exercise foals into their training as racehorses for 2 years, Firth et al. (2011) noted that horses who had been exercised beyond pasture exercise had stronger limb bones, and that the differences between experimental groups persisted until the end of the study (the end of the third year). Training at this age (three years old) was noted to have no significant effect on bone response (Firth et al., 2011).

Beyond the necessary bone growth and strengthening for athletic work, young horses can also be exposed to training necessary to prepare them for their future use. Rietbroek et al. (2007) reported an increase in coordination and balance when training 19 Warmbloods using free jumping (2 days a week) and light exercise in a walker (3 days a week) from weaning until three years of age. They also reported that this training did affect muscle characteristics (fiber type composition, fiber area, oxidative capacity), as the muscles adapted to meet the demands of the training (Rietbroek et al., 2007). It is also recognized that young horses need practice to become accustomed to the weight of a rider and that, initially, poor balance and lack of coordinated movement result in higher muscle enzyme activities, as the horses perform “unnecessary” movements during the early stages of being ridden (Clayton, 2004; Cotrel & Barrey, 2004; Szarska et al., 2014). These elevated enzyme levels can appear in both two- and three-year-old horses adjusting to training (Szarska et al., 2014). The increase in balance and coordination with repetition can also be seen in work by Kusunose and Yamanobe (2002), who tested 2 groups of male Thoroughbreds aged 20 to 22 months. The first group was trained daily (30 mins per day), and the second group was trained intermittently (30 mins per day for 4 days, followed by a 3-day rest period). When both groups were driven and ridden at a walk through a course, the group that was trained daily was able to be significantly more accurate in completing the course (scored off of video recordings utilizing a summing error system).

The age at which a horse begins work may also have significant positive impact on their long-term performance in sport. In that respect, two different streams of exercise research have emerged: those focusing on racehorses, who typically are trained and prepared early for a racing career that can begin at two years old, and those focusing on Warmblood horses, who typically are trained and prepared for work at the age of three or more. The differences in the demands of their respective sports makes for completely different training regimens, and the effects of working young horses have been examined in both groups.

In racehorses, the bulk of the research is focused on prevention of injury, which will be discussed later (section 4.3). Ohmura et al. (2013), however, did examine the use of treadmills as a method of increasing aerobic capacity and running performance without subjecting horses to the weight of a rider utilizing 19 yearlings. They were able to demonstrate improvement for all groups (riding only, short interval runs, and long interval runs) and reported no lameness but were also unable to determine which of the trials was the optimal training method for young horses (Ohmura et al., 2013).

In Warmbloods, Santamaría et al. (2005) followed a cohort of horses (initial n=40 Dutch Warmbloods) from six months of age until five years old. The foals were split into 2 groups: those who received early jump training and those who did not. Jump training involved free jumping 2 times a week and walking in the walker 2 times a week for 30 months. At six months, there were no differences between the groups morphometrically or kinematically; however, when horses were tested again at four years old, the horses who had received jump training as foals did display a different jumping technique, which authors interpreted as the horses having better control over their jumping or more experience at estimating distances (Santamaría et al., 2005). Siegers et al. (2023) recorded fitness parameters (heart rate and lactic acid) on 16 Friesian stallions aged 3 (n=11), 4 (n=3), or 5 (n=2) in response to different training regimens. They found that alternating training intensities (high versus low) improved fitness while also significantly decreasing the risk of overtraining, specifically noting the need for rest days or low intensity days for training Warmbloods (defined as training periods where the horse was not asked to canter).

While donkeys or mules are utilized in athletic activities, such as trail riding, little to no research has been conducted regarding the effects of exercise on their musculoskeletal system.

4.3 Risk of Injury

Beyond increasing skill or potentially bolstering future performance, the risk of injury is also an area of concern when training younger horses. When examining a cohort of racehorses over 2 years, lameness is the most common reason that horses fail to train during a given period of time (Dyson et al., 2008). In Dyson and colleague’s (2008) examination of 56,601 total training days for two year olds, and 29,369 days of training for three year olds, two-year-old horses had a significantly greater proportion of days that they couldn’t train when compared to three year olds, and lameness (specifically stress fractures) was the most frequent cause. Recently, researchers have examined this topic in detail to determine if younger horses were at a greater risk of injury and, if so, what were the risk factors that contributed significantly to these negative outcomes. Logan and Nielsen (2021) conducted a review of epidemiological studies to examine these risks in two-year-old horses, ultimately determining that young horses were not at a significantly greater risk of injury and were not at a greater risk for retiring from racing (Velie et al., 2013). In contrast, older horses (four years old), horses who lacked exercise before a race (e.g., 21-day to 2-month rest period prior to returning to racing), and horses who started their racing careers at older ages had an increased likelihood of musculoskeletal injury (Stover, 2003; Hitchens et al., 2019). Bone modeling and remodeling occurs more efficiently in younger horses in response to high-intensity exercise, which may account for the increased risk of injury in older horses (Heleski et al., 2020). This increased risk may also be impacted by the decreased adaptability of tendons with age, specifically the superficial digital flexor tendon, which operates at near maximum biochemical capacity once mature (Dowling & Dart, 2005; Docking et al., 2012).

Where two-year-old horses suffered the most injuries when compared to their older counterparts was dorsal metacarpal disease, or "bucked shins" (Logan & Nielsen, 2021), though this was attributed to management given that this condition also can occur in horses of any age at the start of their training. Authors attributed the sudden increase in dorsal metacarpal disease to the change in lifestyle for two-year-old racehorses, who are moved from pasture to stall and then are trained at much higher speeds than they would have normally reached when running freely (Logan & Nielsen, 2021). To avoid bucked shins, studies recommend short-distance high-speed work at a greater frequency, while simultaneously decreasing the frequency of longer distance and low-speed work (Nunamaker et al., 1990; Ross & Dyson, 2010). Additionally, Logan and Nielsen (2021) cautioned against utilizing pain control in lieu of rest or reduced training should problems occur, as it was more likely to compound problems.

With respect to the joint health of young horses, the results speak to deleterious effects at both ends of the spectrum. Van de Lest et al. (2002) confined five-month-old foals in box stalls and were able to demonstrate that a lack of exercise resulted in "a retardation of the normal development of the joint." However, this process could be reversed when the confined horses were then provided access to pasture, resulting in the resumption of more normal joint development. Just as confinement can damage joint health, so too can overwork. Van de Lest et al. (2002) also reported significant joint harm when young horses were made to sprint an increasing number of 40 metre sprints (12 per day at the beginning of the study and 32 at the end) over a period of 5 months, an excess considered by the authors as being unnatural. Thus, cartilage reacts to both confinement and exercise and can become damaged in the event of no exercise or strenuous activity. A review by Nielsen (2023) also found a similar response to confinement or lack of exercise in bone mass, whereby young racehorses who had been moved from pasture to box stalls in preparation for training showed a significant decrease in bone mass by day 62 of the study despite starting training for work, a decrease that was mirrored in other, similar studies (Nielsen et al., 1997, 1998a, 1998b). This loss of bone mass coincided with the high prevalence of injuries between day 60 and 120 of racehorse training as well as initial racing-related injuries, as bone mass did not increase until day 244 (Nielsen et al., 1997). Follow-up experiments to minimize bone loss from stalling reported that changes in diet (e.g., the addition of calcium at twice the recommended levels) and walking exercise were not enough to prevent the loss of bone mass in horses aged four to seven years old who were trained and then rested for a period of 12 weeks (Porr et al., 1998). Only allowing horses access to pasture (even for 12 hours a day versus full time) prevented the loss, as demonstrated by an experimental cohort of weanlings who were completely pastured, partially pastured, or completely stalled (Bell et al., 2001). When horses from this experiment were all turned out to pasture and radiographed 1 year later, however, all horses had similar levels of bone mineral content, indicating that this loss could be reversed (Nielsen et al., 2000).

Crawford et al. (2021) conducted a matched case-control study (n=202 each of two year olds and a matched horse three years old or older) of racing-age Thoroughbreds to determine the risk factors for musculoskeletal injuries. Factors that increased the likelihood of a musculoskeletal injury were birth order (two year olds that were the first foals born from their dam), preparation time for racing (between 10 to 14 weeks, all ages), and the distance travelled at speed during training (galloping >3 km at 15 m/s for two year olds and 13 m/s for three year olds). Training and exercise, therefore, were not the only risks for injury, and the risk for injury was still present in older horses, even traveling at a lower speed. Nielsen (2023) additionally cautioned against the use of anything that might impede normal bone metabolism, such as pharmaceutical compounds that affect the balance of calcium (e.g., furosemide), as this may contribute to injury despite a well-balanced training regimen.

Despite understanding the potential for injury, as well as many contributing factors, it has been difficult to determine a single ideal amount of training for young horses, particularly for young Warmbloods, who start their training much later than their Thoroughbred and Standardbred counterparts (Siegers et al., 2023). There has been some research into trying to determine a definition for “overtraining” (de Graaf-Roelfsema et al., 2009), and exploration into training optimization using both high- and low-intensity training methods (Siegers et al., 2023). Ringmark et al. (2016) attempted to compare the training regimens of 2 groups of 16 Standardbred yearlings over the course of 2 and a half years. The control group was trained using the standard training menu for Standardbreds in Sweden (after introduction to the cart, trotting 4 days a week for 12 weeks, gradually increasing to a goal of trotting 5 to 7 km at a speed of 5.6 m/s per session), while the experimental group were trained with a 30% reduction in high-intensity distance. Over the course of the study, there were 9 clinical examinations, which found no significant differences in cardiovascular measures or in post-work lactic acid concentrations, but did report that the number of days lost to training were higher in the control group (Ringmark et al., 2016). Though there may be no current ideal training regimen, it is apparent that early, appropriate training and management can help prepare young horses for the demands of their future sports.

4.4 Future Research

1. Further research is needed to define “overtraining.”
2. Further research into the effects of early exercise on the musculoskeletal development of non-horse equids is needed.
3. Further research is needed to determine the effects of pharmaceutical compounds that affect the balance of calcium in bones and the potential for injury.
4. Further research, utilizing different breeds, is needed to determine if an ideal, physiologically-supported training regimen exists for young horses.

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