

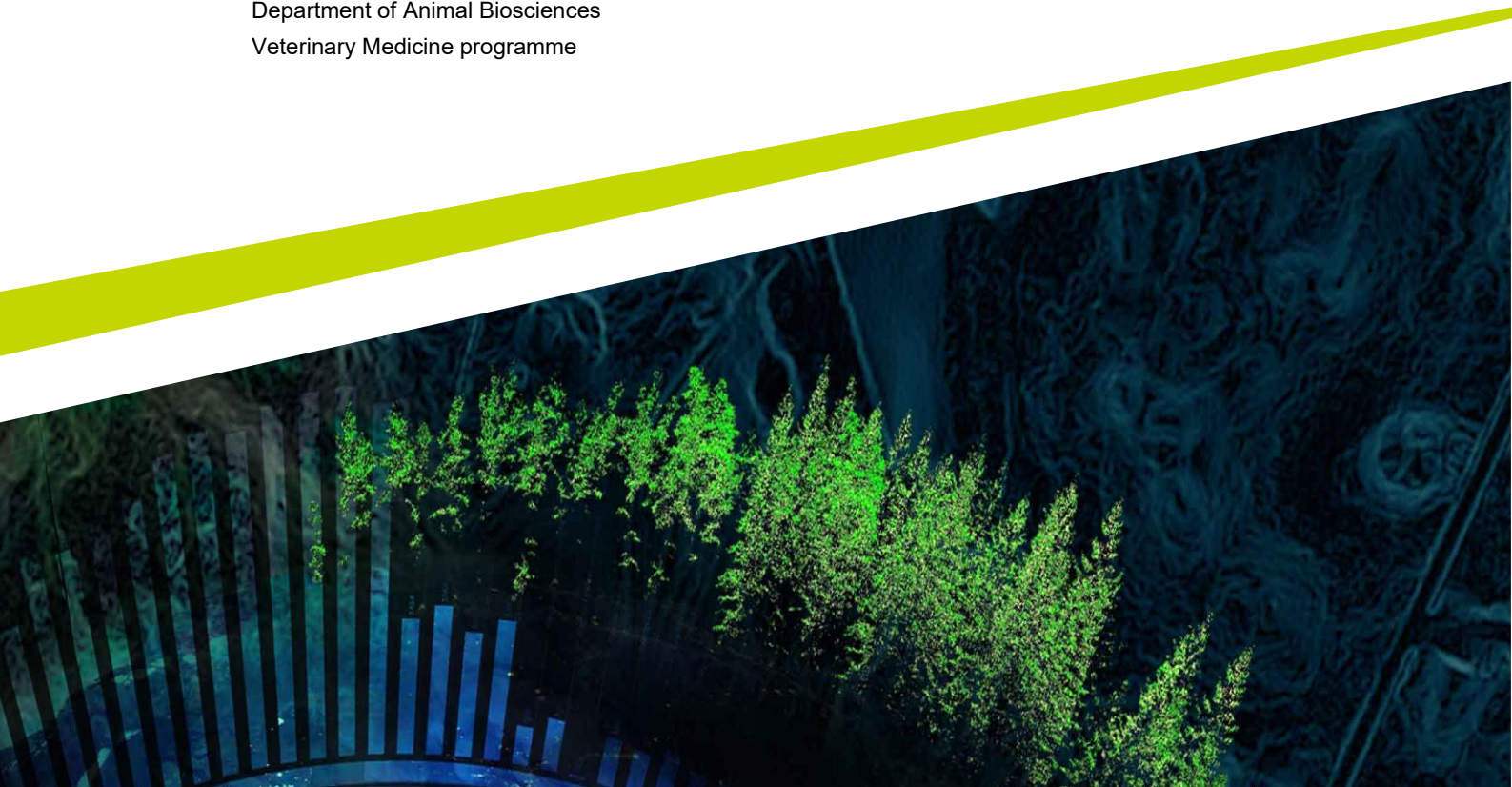


Methods for assessment of lameness in horses

Limitations and possibilities

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Abstract

With lameness being one of the most common reasons for a visit to the veterinarian, there is a high demand for reliable lameness evaluations. Nowadays, these include both the subjective visual assessment, as well as the more recently developed objective quantification. Visual assessment includes several different parts where the veterinarian observes the horse in motion. This includes the different gaits, with the walk and the trot being the most common ones due to them being symmetrical. Additionally, the horse is observed on the lunge, where asymmetries might be enhanced, and after the use of techniques such as flexion tests and diagnostic analgesia, which is used to locate the source of pain. To help with communication concerning the severity of the lameness, there are several grading scales in use, though neither of them is universally accepted. There has also been published a pain ethogram specifically for the ridden horse, though this has been criticised for yet being too vague and in need of development before it is ready to be applied in clinical situations. The visual lameness assessment has limitations, including disagreement between different veterinarians regarding lameness severity and which limb is primarily lame, as well as the possibility for inherent laterality in the horse and compensational lameness. In more recent years, different systems for objective quantification of lameness have been developed, and while they have their own limitations, they offer the possibility bridge the gaps in the subjective visual assessment by complementing it. This gets us closer to the goal of accurate lameness evaluation that leads to effective treatment of this so frequently seen issue.

Keywords: lameness, visual assessment, objective quantification

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1. Introduction

Lameness is one of the most common health problems in horses, and a correct diagnosis is crucial for proper treatment (Dyson et al. 2008; Egenvall et al. 2009; Murray et al. 2010). Lameness is usually evaluated subjectively through visual assessment, but despite the importance of a correct diagnosis it is not unusual to see differences in the assessment of lameness in and between veterinarians, resulting in a risk of it going unnoticed or being identified to the wrong limb (Keegan et al. 2010; Hammarberg et al. 2016). Lameness might show itself differently in different horses and in different gaits or other types of movements, and due to this it is of relevance to study the horses' movement during several circumstances; on both soft and hard surfaces, on straight lines and on the lunge, and in different gaits (Dyson 2014; Dyson & Greve 2016; Hammarberg et al. 2016). However, no study has yet been made where each of these conditions have been included, and the limitations to the visual assessment might make it less reliable than desired.

Some promising complements to the visual assessment are the different types of technology that has the ability to objectively measure asymmetries in the gait of a horse (Hardeman et al. 2022). This includes both stationary force plates and body-mounted inertial sensors, who makes it possible to document differences in movement between the left and the right part of the body (McCracken et al. 2012; Hardeman et al. 2022). This technology offers information on how lameness leads to changes in gait symmetry and is a valuable tool both in assessment of which limb is lame, and to which degree, along with limiting expectation bias during assessment, for example while using diagnostic analgesia (Barrey et al. 1994; Leelamankong et al. 2020; Hardeman et al. 2022).

The purpose of this literature review is to look into how lameness is assessed visually, what difficulties it entails, and which methods there are for objective quantification.

2. Materials and method

This is a literature review of studies performed on lameness in horses; how it is visually assessed, the difficulties with that type of assessment, and what types of objective quantifications there are.

Published works were searched for primarily through Google Scholar, with the search words ‘horse* AND lame* AND (assess* OR evaluate*)’, ‘body-mounted inertial sensor’, “diagnostic analgesia” AND horse*, laterality AND horse* AND lame*, “stationary force plate” AND lame* AND horse*. In addition to this, the book that is used as a reference (*Diagnosis and Management of Lameness in the Horse*, by Michael W. Ross and Sue J. Dyson) was found on Google Books, using the search words “lame” and “horse”.

The references that have been used have been found on the following websites: British Equine Veterinary Association Publications (BEVA) Online Library, American Veterinary Medical Association Publications (AVMA), ScienceDirect, VetRecord and MDPI.

3. Litteraturstudie

3.1 Scales for quantifying lameness in horses

There are several different lameness grading scales currently in use (Dyson 2011; Gómez Álvarez & Oosterlinck 2023). The purpose of them is to help with communication and keeping of records, as well as determining the severity of the lameness itself. They usually range from sound to no weight-bearing ability, with a different number of steps in between, where each step has a definition that describes the state of lameness at that level. None of the existing lameness scales are universally accepted, since they all have limitations and can not take into consideration all circumstances of a lameness assessment, as well as individual differences in how a horses adapt their gaits when lame (Dyson 2011).

In North America the most commonly used grading scale is the AAEP scale (Ross & Dyson 2010). The AAEP (American Association of Equine Practitioners) has developed this lameness grading system ranging from 0 to 5, with each step in the scale described in Table 1.

Table 1: The AAEP lameness grading scale

0.	Lameness not precepted under any circumstance.
1.	Lameness is difficult to observe and is not consistently apparent, regardless of circumstance (e.g. under saddle, circling, inclines, hard surface, etc.).
2.	Lameness is difficult to observe at a walk or when trotting in a straight line but consistently apparent under certain circumstances (e.g. weight-carrying, circling, inclines, hard surface, etc.).
3.	Lameness is consistently observable at a trot under all circumstances.
4.	Lameness is obvious at a walk.
5.	Lameness produces minimal weight bearing in motion and/or at a rest or a complete inability to move.

This system is potentially confusing since it counts in both walk and trot, and does not offer any alternatives for when, for example, there are signs of lameness in walk but not in trot (Ross & Dyson 2010). In some cases, a modified AAEP scale is used, with half-steps between the before mentioned steps to allow for more diversity and for when a horse fits in between two steps of the original scale (Hardeman et al. 2022). This doubles the amount of steps, which makes this modified scale very similar to the 1-10 grading system that is mostly used in Europe (Ross & Dyson 2010).

A different system grades the walk and the trot independently, which makes it possible to take into account that in some cases the lameness is more prominent in the walk (Ross & Dyson 2010). Ross and Dyson describe the scale as a relatively simple one ranging from 0 to 8, with 0 representing soundness and 8 represents non-bearing lameness. During the evaluation the horse is shown in-hand in straight lines and in circles on both soft and hard ground, as well as ridden (Ross & Dyson 2010).

3.2 The Ridden Horse Pain Ethogram (RHpE)

A study has showed that nearly 50% of sport horses have a lameness or other pain-related gait abnormality that has gone undetected by the rider (Greve & Dyson 2014). An ethogram called The Ridden Horse Pain Ethogram has been developed as a way to enable lameness detection and grading when the lameness is more, or exclusively, apparent while the horse is ridden (Dyson & Greve 2016). The ethogram is the first of its kind and consists of 24 different behaviours that are stated to be more commonly observed in lame horses than non-lame horses while ridden, where the occurrence of 8 or more behaviours is said to indicate musculoskeletal pain (Dyson et al. 2018a).

Table 2: *The Ridden Horse Pain Ethogram, adapted from Dyson et al. 2018 (Dyson 2022).*

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

The creators state that in order to properly utilise the RHpE, the assessor needs to be well acquainted with the definition of each of the behaviours in the ethogram, and certain factors such as arena surface, a potentially incorrectly sized bit, or whether the horse's scleras are naturally visible due to small irises need to be taken into consideration (Dyson 2022). Dyson also highlights the importance of observing the horse from both sides as well as from the front and from the back to lessen the risk of some behaviours being missed. It is mentioned that it is generally of interest to assess the full repertoire of movements that the horse can perform, including in straight lines and in circles, as well as in all gaits in varying degrees of collection in order to uncover those who potentially cause a higher degree of discomfort in the case that the horse has a more discreet lameness (Dyson 2022).

However, this ethogram has received criticism regarding a number of shortcomings. In a review published by Ladewig et al. (2022) these shortcomings were highlighted, resulting in a conclusion that the current version of the ethogram is not suitable for diagnostic use. While it is admitted that it can be used as an aid in identifying pain-related behaviours, the definitions that are used are too vague and often do not specify the limit between what is considered normal and what is not, e.g. in terms of frequency or severity of the displayed behaviours. This gives room for subjectivity, which is one of the several conditions of a horse ethogram that this one does not fulfil (Ladewig et al. 2022). Additionally, Ladewig et al. (2022) point out that the ethogram grades each behaviour equally, indicating that they are all of equal weight when in reality it can not be assumed that all behaviours contribute equally to the presumed disorder. The authors of the review also bring forth factors other than pain that can incite the mentioned reactions, such as conflict behaviours, lateralization, the skill level of the rider, faulty equipment and earlier training of the horse. Thus, the Ridder Horse Pain Ethogram seems to have potential, but needs to be further developed in order to become a reliable tool in diagnosing lameness (Ladewig et al. 2022)

3.3 Visual assessment of lameness

It is a standard of practice to watch the horse in motion to evaluate lameness (Dyson 2022). There are a great number of ways to do this, with many different factors that might affect the expression of lameness (Ross & Dyson 2010; Bowen et al. 2023). The horse can for example be shown in-hand or ridden, on hard or soft surfaces, in a straight line or circling, in all gaits, and in transitions between gaits (Hammarberg et al. 2016; Hardeman et al. 2022; Bowen et al. 2023). The most commonly used way is to watch the horse in a walk and in a trot in-hand in a straight line on a hard surface, both towards and away from the evaluator, as well as viewed side-on

(Bowen et al. 2023). The hard surface affects the horses' movement as well as helps the evaluator detect asymmetries through sound, though it is important to recognize that other factors can also be the cause of the sound of an asymmetrical gait, such as loss of a shoe, resulting in confounding of interpretation (Ross & Dyson 2010).

Apart from walking and trotting on a straight line, it is also common to lunge the horse on a soft surface during the assessment (Rhodin et al. 2013). This is due to the circling causing the horse to compensate with natural asymmetries of gait and position of the head that might enhance the lameness (Ross & Dyson 2010; Rhodin et al. 2013). However, lunging must be done both to the right and to the left, since the circle induced asymmetries might also hide the lameness (Rhodin et al. 2013). The study by Rhodin et al. (2013) shows that when trotting on a circle, a horse naturally acquires a movement asymmetry resembling a low-grade inner impact hindlimb lameness which then works as an enhancer if the horse is actually lame in that same limb. This asymmetry then also helps to mask certain types of mild lameness in the outer hind limb by balancing the movement in the pelvis, making it more symmetrical when a non-lame horse would have the slight circle-dependent asymmetry. In contrast to the hindlimb lameness being more apparent on the inner hindlimb, forelimb lameness is most pronounced when the lame limb is the one on the outside of the circle (Rhodin et al. 2013). In addition to asymmetries, both the diameter of the circle and the speed with which the horse is moving affects the expression of lameness (due to body lean angle) and consequently the assessment (Pfau et al. 2012). A smaller circle and/or higher speed will cause a higher degree of body lean towards the centre of the circle, and lameness may affect this angle depending on whether the lame limb is on the inside or the outside of the circle (Pfau et al. 2012).

Another method that is commonly seen in lameness examinations is the flexion test, where pressure is applied to a joint for the purpose of exacerbating less apparent lameness (Marshall et al. 2012). The flexion tests can induce a low to medium high grade of lameness in horses that are otherwise deemed as sound (Dyson & Greve 2016). However, the guidelines for these tests are not always entirely clear, with the recommendations concerning the amount of force applied and for how long it should be applied varying between different sources (Keg et al. 1997). In the study performed by Keg et al. (1997), flexion tests were performed on clinically sound horses, and it is shown that an increased applied force and/or time under pressure leads to a larger number of horses expressing lameness, implying the importance of those two factors. The lack of scientific data on the amount of force and the duration of force application are assumed to lead to a lack of precision during the flexion test (Busschers & Van Weeren 2001), and for the test to be objective and reliable

through reproducibility, the discussed factors would need to be standardised (Keg et al. 1997).

As mentioned earlier, it is most common to evaluate the horse in the walk and in the trot (Bowen et al. 2023). This is likely due to the gaits being symmetrical (Byström et al. 2018), allowing the evaluator to compare left-right differences in limb placement, withers and pelvis (Byström et al. 2018; Marunova et al. 2022). However, in some cases it can also be of interest to observe the horse in canter (Dyson 2014). Dyson (2014) states that while it may be difficult to identify the specific limb that is lame, it can be possible to observe abnormalities such as placing the hindlimbs closer together, four-beat canter, trailing hindlimbs, unwillingness to sustain canter, and changing the leading leg in the hindlimbs.

It has been suggested that in some cases, lameness is most accurately assessed while the horse is being ridden, for example if the horse is only mildly lame in-hand or if the rider reports lameness only under saddle or during certain ridden movements (Ross & Dyson 2010). While rider skill level has not been shown to affect the lameness of the horse, it does have an impact on the gait quality, which might affect the lameness assessment (Dyson 2022; Dyson et al. 2022a). In terms of the RHpE, it means that the horse may exhibit different specific behaviours associated with musculoskeletal pain with different riders (Dyson 2022).

When pinpointing the source of pain in a lame horse, diagnostic analgesia is an often useful tool (Ross & Dyson 2010; Pfau et al. 2012). The goal is for the local analgesia to cause changes in locomotion that are detectable when compared to the assessment before the analgesia was used (Pfau et al. 2012). The locomotive changes that can be observed are a change of speed, stride length or rhythm, and body lean angle in circles, as well as an improved gait quality and performance (Barstow & Dyson 2015; Dyson et al. 2018b). The analgesia can be given to anatomical structures in a sequence from distal to proximal if the source of pain is largely unknown, but in those situations where there is a known pattern among previous cases, a more specific target area could be chosen as the first option (Ross & Dyson 2010). However, when using diagnostic analgesia there is a risk for false positive responses, primarily due to some cases of subtle lameness improving or resolving during exercise, or false negative response due to that the re-evaluation have not been made before the anaesthetic fluid has diffused into surrounding structures (Nagy et al. 2009; Schumacher et al. 2013). It has also been shown that bias might affect the interpreted results (Arkell et al. 2006).

Apart from assessing lameness and asymmetries in movement, it could be of interest to observe certain behaviours at rest that might be connected to pain (Ask

et al. 2020). Pain face has been suggested as such a tool, but varying results have been acquired regarding its utility, with it not being present at rest in all horses with low grade lameness (Ask et al. 2020) or barely present at all (Anderson et al. 2023). In the study by Ask et al. (2020) it is concluded that when pain face is present it does have a strong correlation with lameness, but also that there are more reliable indicators, such as posture. Anderson et al. (2023) instead highlight the inconsistencies in assessment of facial expressions by trained animal welfare specialists as well as in the assessment of lameness in motion by veterinarians, and call for a more objective form of assessment.

3.3.1 Limitations to visual assessment of lameness

Even with the wide arrange of methods in use, several studies have shown that there are differences between clinical practitioners regarding the assessment of lameness (Fuller et al. 2006; Keegan et al. 2010; Hammarberg et al. 2016; Leelamankong et al. 2020; Hardeman et al. 2022). These studies state differences in experience with lameness evaluation, how severe the lameness is, and whether the pain stems from a forelimb or a hindlimb as possible causes of the different observed inter-rater assessments. Additionally, with the use of diagnostic analgesia follows a risk for bias when interpreting results (Arkell et al. 2006).

Several studies have shown that the agreement between veterinarians on which limb is lame and the severity of the lameness can be graded as moderate at best (Hewetson et al. 2006; Keegan et al. 2010; Hammarberg et al. 2016). The agreement between more experienced veterinarians is higher than between moderately experienced or inexperienced groups (Hammarberg et al. 2016; Leelamankong et al. 2020). The intra-rater agreement is also higher for the experienced practitioners (Keegan et al. 1998). Additionally, when determining whether a horse is lame or not, the agreement between veterinarians is higher for straight line trials (Keegan et al. 2010) than for assessment during lunging (Hammarberg et al. 2016). It is hypothesized that this could be because of the aforementioned asymmetries that are naturally induced when the horse moves in a circle, which might make the assessment more difficult (Pfau et al. 2012; Rhodin et al. 2013; Hammarberg et al. 2016). Along with that, the results attained in studies by Hammarberg et al. (2016) and Keegan et al. (2010) suggest that evaluation of hindlimb lameness is more challenging than for forelimb lameness, which might affect the level of inter-assessor agreement.

The severity of lameness also affects rater agreement, where grades lower than 1,5 on the AAEP scale yields significantly lower levels of agreement than the higher grades (Keegan et al. 2010). Experienced evaluators have been shown to be able to more accurately detect lameness of lower grades, but given the limitations of human

visual asymmetry perception it is uncertain whether more specific grading of subtle lameness is possible without the help of kinetic or kinematic analysis (Parkes et al. 2009). When comparing the results given by veterinarians in live clinical evaluations of lameness and those attained from concurrently used body-mounted inertial sensors, more experienced clinicians generally exhibited a stronger agreement than those less experienced (Leelamankong et al. 2020).

Apart from differences in inter-rater agreement, the study by Keegan et al. (2010) also brings attention to the difficulties in determining which leg is the predominantly lame one. This is possibly due to compensatory lameness that appears as an indication of load redistribution in order to avoid putting strain on the limb where the pain stems from (Weishaupt et al. 2006; Maliye et al. 2015; Maliye & Marshall 2016). It is not uncommon for horses with hindlimb lameness to develop a compensatory ipsilateral forelimb lameness, with typical signs of forelimb lameness such as a head nod (Maliye & Marshall 2016). Similarly, forelimb lameness can lead to perceived compensatory hindlimb lameness, where instead the contralateral hindlimb is the one most affected (Maliye et al. 2015). Whether ipsilateral hindlimb lameness is also a possible response is unclear, with different studies yielding different results (Uhlir et al. 1997; Weishaupt et al. 2006; Maliye et al. 2015). Compensatory lameness is expected to improve after the use of diagnostic analgesia on the primarily lame limb, whereas if it remains it is implied to not be connected to the assumed primary lameness (Maliye & Marshall 2016). In the case of a bilateral lameness in either forelimbs or hindlimbs, another issue might arise; the detection of the lameness when the horse is shown in hand might be made more difficult due to the possibility that the lameness is expressed equally on both limbs, for example as short-stepping, resulting in the gaits still being symmetrical and therefore masking lameness that is otherwise spotted through asymmetry (Dyson et al. 2022b).

With asymmetry often being used as an indicator of pain with lameness as a result, the presence of functional motor laterality might prove to be a problem. Laterality can be described as an inherent asymmetry in the structure or function of the nervous system (Byström et al. 2020), and has been confirmed in horses in several studies (McGreevy & Rogers 2005; Murphy et al. 2005; Williams & Norris 2007; Murphy & Arkins 2008; Byström et al. 2018). It has been discussed whether this preference for one side could be because of uneven training, with it being standard to approach and handle horses on their left side (McGreevy & Rogers 2005; Williams & Norris 2007), or if it is a wholly natural phenomenon (Lucidi et al. 2013). Lucidi et al. (2013) noted that the majority of previous studies on the subject had been carried out on adult horses, whose presumed laterality might be under the influence of earlier training and handling, and instead conducted a study on foals

and young horses who had been handled bilaterally. The study showed that the foals are more ambidextrous, while the young horses show a motor bias to one side, most commonly the right, leading to the conclusion that while motor laterality does come naturally, it is likely to develop over time.

The current challenge is to determine whether the asymmetries that a horse exhibits are due to the individual laterality or to pain (Rhodin et al. 2017). The measured values of asymmetry in horses that have been deemed as sound by their owners have been shown to overlap with the values measured both from horses with induced and with naturally occurring lameness (Rhodin et al. 2013, 2017; Maliye et al. 2015; Maliye & Marshall 2016). There seems to be no clear line between natural asymmetry and lameness-induced asymmetry that can be measured objectively, resulting in a need for a full lameness examination including the use of diagnostic analgesia in order to determine whether it is pain-related (Rhodin et al. 2017).

It has been shown that a large number of horses that are deemed as sound by their owners in fact show asymmetries in their motion pattern (Greve & Dyson 2014; Dyson & Greve 2016; Pfau et al. 2016; Rhodin et al. 2017). The reason for this could be that the circumstances under which the owner-performed lameness assessment is conducted differs from that of the one made by a veterinarian, but also possibly due to there being no perceived decrease in performance, a common reason for referral to a veterinarian for an examination (Rhodin et al. 2017). On the topic of performance, movement symmetry is an often sought after but seldom achieved goal within equestrian sports (Byström et al. 2020) but the question is how much of the perceived laterality can be credited to the horse, and how much can be credited to the rider. Motor laterality has been shown to increase when the horse is being ridden (Schwarz et al. 2022), and while experienced riders might be able to improve the asymmetry, inexperienced ones might instead enhance it, either by letting the horse work more on the preferred side (Byström et al. 2020) or unknowingly through the inherent laterality of the rider itself causing imbalances in the riding technique (Kuhnke et al. 2010). Generally, the movement of the horse would need to be inspected regularly to enable detection of changes in symmetry and potentially determine whether the rider might be the cause of it (Rhodin et al. 2017).

With diagnostic analgesia being an important tool for determining if laterality is caused by redistribution of weight bearing, and in that case where the pain causing the redistribution stems from, it is important to also note the risk for expectation bias. Especially in the case of milder lameness that is more difficult to detect and grade, there is a higher probability that the assessor perceives an improvement if

they know that an anaesthetic nerve block has been applied than when they think that it has not (Arkell et al. 2006). In this study by Arkell et al. (2006) it was shown that experts in equine orthopaedics and last-years veterinary students are more consistent than non-expert clinicians in their assessment before and after being made aware of the usage of nerve blocks, indicating the importance of evaluating lameness regularly in order to properly utilize and obtain accurate results from diagnostic analgesia.

3.4 Objective quantification

With the limitations to visual lameness evaluation comes a need for a way to objectively quantify lameness in horses in order to offer the correct treatment (McCracken et al. 2012; Maliye et al. 2013). While the human eye has a high capability to detect disturbances in symmetry, it is still below or just enough to identify important asymmetries related to lameness (Ross & Dyson 2010). This becomes increasingly evident in the case of low grade lameness (Parkes et al. 2009), which as sforementioned results in a lower degree of agreement within and among veterinarians (Keegan et al. 2010). Objective quantification systems can detect deviations that are smaller than those apparent to the naked eye, making it possible to diagnose these less obvious cases of lameness (McCracken et al. 2012). Additionally, the objective systems have proven to be more reliable due to their repeatability (Keegan et al. 2011) and the fact that they are unbiased, making them especially beneficial when diagnostic analgesia is being used (Keegan et al. 2013; Hardeman et al. 2022).

There are several systems that can be used to objectively quantify asymmetries, with different technology being suitable for different settings. Stationary force plates and stationary camera-based kinetic evaluation of movement are mostly used in research on lameness, since the first requires dedicated space and technical expertise to use, and the second needs specific controlled conditions in order to acquire accurate evaluation (Keegan et al. 2011). For field practice, body-mounted inertial sensors seem to be a more versatile and useful tool (McCracken et al. 2012; Keegan et al. 2013). They use sensors that are attached to different parts of the horse's body, such as the head, withers and pelvis (Parkes et al. 2009; McCracken et al. 2012; Keegan et al. 2013; Hardeman et al. 2022; Marunova et al. 2022). The sensors measure either acceleration or angular velocity and then transmits the data wirelessly to a computer, allowing the movement to be analysed through these measurements (Keegan et al. 2013). Lastly, a more recent type of objective quantification can be used even by owners through an app where a video is taken of the horse in movement and subsequently sent to be analysed by AI (Lawin et al. 2023). While Lawin et al. (2023) acknowledge that while the technology is not quite

as precise as the body-mounted inertial sensors, it is still able to measure and detect lameness at a level that is relevant for the users.

3.4.1 Limitations to objective quantification

Although these different systems for objective quantification of lameness have proven to be useful, they still have their limitations. Firstly, since they only measure objectively, they do not take into account other signs of pain that might differentiate between naturally occurring asymmetry and that which is caused by pain (Keegan et al. 2012, Keegan et al. 2013). Secondly, bilateral lameness could be interpreted as the horse being sound if both lame limbs have an equal severity of lameness, or as unilateral lameness if the lameness is worse in one limb than in the contralateral one, both scenarios leading to the lameness being underestimated (Keegan et al. 2013). The conclusion that can be drawn from this is that objective quantification should not be used on its own, but rather as a supplement to the subjective lameness work-up routine (Keegan et al. 2013; Greve & Dyson 2020; Hardeman et al. 2022).

4. Conclusion

In this literature study the common techniques for visual and objective lameness assessment has been reviewed. With lameness being one of the most frequent causes for referring a horse to a veterinarian, it is of utmost importance for the veterinarian to be able to accurately locate and grade the lameness in order to provide sufficient and relevant treatment. The subjective visual assessment is what has solely been used in the past, with other methods not yet being developed or available. It includes viewing the horse in different movements on different surfaces, as well as the use of tools such as diagnostic analgesia and flexion tests in order to detect asymmetries that are believed to be caused by musculoskeletal pain. Several grading scales are currently in use, though none of them has been universally accepted as the superior one, and the one published pain ethogram for the ridden horse has been met with certain criticism, calling for the need for more development.

With the limitations that come with subjective evaluation, there has been a need to fill out the gaps in order to make a more reliable assessment. The objective quantification methods that have been developed in more recent times has potential to be a useful tool in the quest to fill out these gaps, but just like the subjective methods it has its flaws. However, when used correctly, it seems probable that the objective and the subjective methods can complement each other enough to minimize their respective limitations. This gives the veterinarian the opportunity to provide an overall more trustworthy assessment, resulting in an effective and accurate treatment that benefits all parties involved.

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