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This review accompanies the relevant episode of the Cutting Edge veterinary podcast. In each episode of this podcast, 3rd year students in the University of Calgary's veterinary medicine program fill you in on the most up-to-date literature and evidence-based practices on topics that matter to you, the practising veterinarian.

Gait Analysis Technology and Its Role in The Diagnosis of Equine Lameness

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There is no shortage of research showing that even the experts struggle to accurately diagnose lameness, simply due to the limits of the human eye in detecting movement asymmetry. To further complicate the picture, there is inherent bias that exists in interpreting flexions or diagnostic nerve/joint blocks due to knowledge of the procedures being performed. It becomes obvious that, in order for us to advance in our accurate detection and therefore appropriate management of lameness, we must advance our diagnostic capabilities.

A 2009 study[1] published in the Equine Veterinary Journal set out to assess the ability of the human eye to detect asymmetry in two moving objects, as it relates to the assessment of equine lameness and movement asymmetry. The results of their study found that the threshold for detection of asymmetry was 25% for all individuals in the study, regardless of training, when evaluating artificial simulations. The study concluded that the rather limited ability of the human eye to perceive asymmetry, which is one of the fundamental elements of the lameness exam, highlights the need for additional diagnostics and technologies as part of a complete lameness assessment.

A 2010 study[2] looked at the agreement between equine veterinarians in their lameness assessments. They used 131 horses, which were evaluated for lameness by several clinicians with a combined average of about 19 years of experience, using the AAEP lameness scale from 0-5. They first watched the horse trot in a straight line only and then also graded the horses after a full lameness evaluation. The criteria for agreement between veterinarians was defined in the study by agreeing on the same limb being lame, regardless of the severity score that was assigned. After only evaluating the horse at a trot in a straight line, there was about 77% agreement between observers, and after a full lameness exam, agreement actually decreased to about 73%. Agreement on forelimb lameness was slightly higher than on hindlimb lameness. When the lameness was more severe, with an average AAEP lameness score of greater than 1.5, practitioners were in agreement 93 % of the time, but when the lameness was more mild (average score was less than or equal to 1.5) they agreed only around 62%of the time. Presenting those numbers differently, this means that about 38% of the time, when a horse is mildly lame, clinicians will not be in agreement on which leg is lame. This could have huge implications not only on achieving an accurate diagnosis, but on how that horse is managed. Clearly, our subjective assessment of lameness lacks accuracy, and there is a great need for objective lameness assessment tools.

Research shows that flexion tests are also not without problems of their own.[3] Flexions of the distal limb were performed by the same researcher in 100 clinically sound horses under standardized conditions. Over 60% of the 100 sound horses had a positive flexion test. Of these, about 50% showed a slight lameness, 35% a mild lameness, and 15% a distinct lameness. It was concluded that more than half of clinically sound horses will have an at least slightly positive flexion test of the distal limb. Therefore, this brings into question the value of flexions in detecting and localizing joint related lameness. For the second part of the study, flexion tests were repeated, at intervals of 10 min, 30 min, 48 hours and 6 months in 23 horses to assess repeatability of results. It is not uncommon to repeat flexion tests in the same horse, as is sometimes done over short intervals during the same lameness examination, especially when nerve or joint blocks are performed. Flexions may also be repeated in the same horse over a much larger interval in the case of repeat pre-purchase or insurance examinations. When repeating the flexion test with short intervals of 10 and 30 min, the score increased significantly after the second test. Repeated flexion after 48 hours did not result in a significantly different outcome, and over a 6-month period, the outcome of the test decreased significantly. For the 10 and 30 minute repeat flexions, the authors discussed that it is likely that the oxygen debt produced in the joint is not able to be eliminated before the next flexion test, and a cumulative effect may be occurring. The results of this study suggest that such a situation may exist after two or more flexion tests are performed. Therefore, it should be concluded that a flexion test can only be repeated once within a short time interval without the risk of having a cumulative effect interfering with the results. However, when nerve or joint blocks are performed during a lameness exam, it is very common to perform flexions multiple times in the same horse over the course of the same exam, which raises some questions about the accuracy of this practice. The flexion test was not consistent over a 6-month period, demonstrating that the long-term consistency of the test is limited and has little accuracy is predicting future joint related problems.

There have also been studies to show that our interpretation of nerve blocks as part of a lameness exam is biased by our knowledge of the procedure that was performed.[4] To demonstrate this, researchers displayed video clips of horses taken before and after performing a nerve block, and then manipulated whether the observer had knowledge of the procedure or not. They used 18 observers which graded the lameness of 8 different horses on a scale of 0 to 10. The average difference in lameness grade changed by 0.4 once the observer knew that a nerve block had been conducted. When the same individual was asked to grade the same horse on two occasions, there was an average difference of 0.6 in the grade they assigned to the same horse. Of the 18 observers in the study, 4 of them were orthopedic experts, and the agreement between these expert observers was within one grade. However, the other 14 observers were non-experts and final year vet students, and the agreement between them was significantly worse, which shows that experience plays a role as well. The authors of the paper highlighted that these results show that there is clear bias and lack of repeatability in subjective lameness assessments, and further discussed how these results might impact horses that are only slightly lame (around an AAEP grade 1). A bias of 0.4 or a repeatability of 0.6 should not drastically change the diagnosis of a moderately or severely lame horse, but it could have serious implications for those slightly or intermittently lame. This is true for both the diagnosis of lameness and monitoring improvement with treatment.

Moving on to the research surrounding lameness locating technology itself, there is plenty of evidence supporting the legitimacy of the body mounted inertial sensors that are most commonly used. It has been shown for over 10 years now that inertial sensors placed on the poll, over the pelvis, and on the distal limb are incredibly accurate and precise in locating lameness.[5] In 2011, Keegan et al. documented the repeatability of lameness location with wireless inertial sensors, following the 2004 study[6] that indicated the technology's ability to specifically identify a lame limb. When compared to another objective lameness locator, a stationary force plate, the wireless body mounted sensors agreed with the force plate data and detected the lame limb in horses with forelimb lameness trotted in a straight line.[7] This agreement indicates that the wireless sensor based technology is capable of detecting lameness in the correct limb in an objective way. Wireless sensors are non invasive, easy to apply, and data collection occurs in real time, which is favorable in a practice setting. Namely, the equipment time has been recorded as less than 3 minutes.[5]

In researching the available technologies, there are a few options that have great potential to be an asset in everyday practice. Firstly, the Equinosis Q with Lameness Locator seems to be the most heavily researched. It uses sensors placed on the head, the pelvis, and the right front pastern which transmits movement data to a portable tablet.[8] Second, as of 2022, there is potential relevance of another system called the Lameness Detector 0.1.[9] This system works by placing an inertial sensor on the dorsal pastern of each limb and the recent research[9] found that measuring increases in accelerometric impulses in the x axis was most associated with lameness in a limb. This is another example of an application that may be available in the future that would be extremely easy to apply to general practice with ease of use practicality. Lastly, Sleip is a new, sensorless, smartphone-based product that uses video and an artificial intelligence program to detect and document movement asymmetry.[10] There has yet to be research documenting the repeatability and applicability of the Sleip program, but it is definitely an exciting prospect and could be a valuable addition to daily practice.

The Equinosis boasts being easy to use as there are only 3 wireless sensors and the portable tablet, making it applicable in hospital and on farm. The technology is well documented in the literature and its function is easy to understand from a practical perspective. The sensors on the head and pelvis measure vertical acceleration that is then translated to a vertical position.[11] The forelimb sensor then relates the vertical movement to the timing of the stride at the trot in order to associate the dorsal asymmetry measurements with a limb and the phase of the stride. The data is transmitted wirelessly and in real time.[8] This allows the technology to immediately provide a report that documents the amplitude of asymmetry and the phase of the stride that the horse is feeling pain, namely, during push-off, mid-stride, or during impact. There are a few other commercially available systems, called QHorse, Equimoves, and Equigait, which use similar technology, sensors, and sensor placement. However, the majority of our research surrounded the use of the Equinosis Q with Lameness Locator and it is the most commonly used in general practice.[12]

In a recent interview[13] with Dr. Ron Genovese, he stated that the introduction of new tools to the lameness workup has always brought some resistance from practitioners. Interestingly, he speaks of the initial hesitancy to use an ultrasound machine to identify soft tissue injury. To explain the perceptions of gait analysis in practice, there has been research[12] surrounding the thoughts of clinicians on this diagnostic tool, and the main concern voiced surrounding its use is an over reliance on technology. There is resistance to new technology due to the fear that the veterinarian's clinical knowledge and experience will be reduced to a simple image or data set. This is of course not true, as there will always be more to the clinical picture of a patient than whatever our tools can tell us. We need to remember that our diagnostic tools can improve "on what the hands can feel, and the eyes can see," and support us through our clinical decision making.[13]

To begin breaking down the benefits of using this technology, the literature discusses applications and client perspective. The potential benefits and applications of this technology is boasted by users.[12] The positives of using lameness locators in daily practice are that there is increased objectivity and transparency in the lameness workup, better diagnoses, and improved documentation of cases. The primary application of this technology is in the workup and diagnosis of lameness. For example, applying this technology before and after blocking will help detect subtle changes that are hard to appreciate otherwise.[12] These subtle changes may also be better detected and documented after treatment as well. Additionally, there is discussion of the application of lameness locators to pre-purchase and wellness exams[12, 13], and the possibility of telemedicine and multidisciplinary teamwork, if its data can be interpreted remotely by practitioners, in the follow up care of a patient. Lastly, in a survey[12], it was noted that 80% of veterinarians thought that their clients were positive about the lameness locators. The clients are able to objectively see changes in the data, allowing them to feel supportive of the outcome and included in the process.

In research using lameness locating technology, there have been some potential limitations identified as well. In one study[14], it was found that 72.5% of horses that were not identified as lame by their trainers, showed asymmetry in their movement. In a follow up study[15], it was found that meloxicam treatment did not significantly alter asymmetry measurements, questioning whether the lameness locators measure asymmetry that is caused by pain at all, or if the dysfunction is merely unresponsive to meloxicam. It was also found that asymmetry measurements may fail to detect bilateral lameness if the asymmetry is the same amplitude on both sides of the body.[16] In this same study[16], it was also questioned whether vertical motion asymmetry may occur due to neurological lameness or anatomic variation. In the clinician perceptions study[12], the technology was scrutinized based on its ability to merely measure vertical motion asymmetry and its inability to differentiate between pain, mechanical, or neurological asymmetries. There were also concerns raised about the interpretation of the data, technical problems, and IT support, which are not considerations to be overlooked. These limitations further exemplify the importance of the veterinarian and their clinical judgment when applying lameness locators to clinical practice and routine lameness diagnosis, in order to minimize the downfalls of lameness locating technology.

In summary, gait analysis technology is the closest we have come to eliminating the subjectivity of visual lameness assessment. This technology can be used as a diagnostic tool as part of the lameness work-up, which of course still relies heavily on clinician judgment. This innovative technology continues to become more practical and accessible, and as we advance in the field of equine sports medicine, it is a necessity. It is important to remember that machines are incapable of assessing an entire clinical picture, meaning that this technology may not replace veterinarians, only improve the quality and efficiency of their clinical judgment. The prospect of using these tools allows us the possibility of considering lameness diagnosis evidence-based medicine.

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References

1. Parkes RSV, Weller R, Groth AM, May S, Pfau T. Evidence of the development of “domain-restricted” expertise in the recognition of asymmetric motion characteristics of hindlimb lameness in the horse. Equine Veterinary Journal. 2009 Feb;41(2):112–7.
2. Keegan KG, Dent EV, Wilson DA, Janicek J, Kramer J, Lacarrbba A, et al. Repeatability of subjective evaluation of lameness in horses. Equine Veterinary Journal [Internet]. 2010 Feb;42(2):92–7. Available from: https://aaep.org/sites/default/files/issues/proceedings-08proceedings-z9100108000260.PDF
3. Busschers E, Van Weeren PR. Use of the Flexion Test of the Distal Forelimb in the Sound Horse: Repeatability and Effect of Age, Gender, Weight, Height and Fetlock Joint Range of Motion. Journal of Veterinary Medicine Series A. 2001 Sep;48(7):413–27.
4. Arkell M, Archer RM, Guitian FJ, May SA. Evidence of bias affecting the interpretation of the results of local anaesthetic nerve blocks when assessing lameness in horses. Veterinary Record [Internet]. 2006 Sep;159(11):346–8. Available from: https://veterinaryrecord.bmj.com/content/vetrec/159/11/346.full.pdf
5. Keegan KG, Kramer J, Yonezawa Y, Maki H, Pai PF, Dent EV, et al. Assessment of repeatability of a wireless, inertial sensor–based lameness evaluation system for horses. American Journal of Veterinary Research. 2011;72(9):1156–63.
6. Keegan KG, Yonezawa Y, Pai PF, Wilson DA, Kramer J. Evaluation of a sensor-based system of motion analysis for detection and quantification of forelimb and hind limb lameness in horses. American Journal of Veterinary Research. 2004;65(5):665–70.
7. Keegan KG, MacAllister CG, Wilson DA, Gedon CA, Kramer J, Yonezawa Y, et al. Comparison of an inertial sensor system with a stationary force plate for evaluation of horses with bilateral forelimb lameness. American Journal of Veterinary Research. 2012;73(3):368–74.
8. Equinosis. Quantify equine lameness [Internet]. Equinosis. 2022 [cited 2023Feb14]. Available from: https://equinosis.com/veterinarians/#the-q
9. Crecan CM, Morar IA, Lupsan AF, Lupsan CC, Rus MA, Repciuc CC. Development of a novel approach for detection of equine lameness based on inertial sensors: A preliminary study. Sensors. 2022;22(18):7082.
10. Sleip. Sleip: Markerless Lameness Diagnostics on your phone [Internet]. Sleip Ai. 2023 [cited 2023Feb14]. Available from: https://sleip.com/
11. Pitts JB, Kramer J, Reed SK, Schiltz P, Thombs L, Keegan KG. Effect of induced hindlimb length difference on body-mounted inertial sensor measures used to evaluate hindlimb lameness in horses. PLOS ONE. 2020;15(2).

12. Hardeman AM, Van Weeren PR, Serra Bragança FM, Warmerdam H, Bok HG. A first exploration of perceived pros and cons of quantitative gait analysis in Equine Clinical Practice. Equine Veterinary Education. 2021;34(10).

13. Loving NS. Bridging the Past to New Technologies [Internet]. Equinosis. 2021 [cited 2023]. Available from: https://equinosis.com/bridging-the-past-to-new-technologies/

14. Rhodin M, Egenvall A, Haubro Andersen P, Pfau T. Head and pelvic movement asymmetries at trot in riding horses in training and perceived as free from lameness by the owner. PLOS ONE. 2017;12(4).

15. Persson-Sjodin E, Hernlund E, Pfau T, Haubro Andersen P, Holm Forsström K, Rhodin M. Effect of meloxicam treatment on movement asymmetry in riding horses in training. PLOS ONE. 2019;14(8).

16. Keegan KG, Wilson DA, Kramer J, Reed SK, Yonezawa Y, Maki H, et al. Comparison of a body-mounted inertial sensor system–based method with subjective evaluation for detection of lameness in horses. American Journal of Veterinary Research. 2013;74(1):17–24.