Pitfalls of objective gait analysis

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The limitations of human perception for the visual evaluation of lameness have been well described, whereby not only classification of mild to moderate lameness but also the correct classification of sound horses as sound poses a challenge, even for experienced veterinarians (Starke and Oosterlinck, 2019). Nowadays, practical tools for quantitative (often referred to as objective) evaluation of lameness are available and this technology has unquestionably increased our understanding of the biomechanics of lameness (Keegan, 2007; Pfau et al., 2016; Greve and Dyson, 2020). A preliminary inventory of perceived pros and cons in equine practice revealed that users of quantitative gait analysis tools were motivated by objectivity, transparency, documentation and client service, whereas non-users mentioned costs and complexity of data interpretation as main issues (Hardeman et al., 2021). However, there are some common misconceptions on the use of objective methods for lameness evaluation, and it should be emphasized that the use of measurements is not replacing the clinician but rather augmenting the clinician’s toolbox. All measurements must be evaluated within the context of the presenting complaint and history, complimentary to further clinical assessment or diagnostic tests (Adair et al., 2018, 2019).

To date, no visual or quantitative lameness assessment approach can claim 100% reliability in classifying a horse correctly. When applying quantitative methods, one should therefore be aware of pitfalls that may confound data and the assessment. Before looking at those pitfalls specific to objective gait analysis, quantitative evaluation may increase one’s awareness of issues which are also often encountered during visual evaluation, and which should therefore not be regarded as pitfalls of solely objective analysis. For example,

‘unstable’ lameness varying in intensity during an evaluation session or between successive days of evaluation can confound both visual and quantitative analysis. Also, variation in trotting speed may confound the assessment of especially hindlimb lameness (Moorman et al., 2017a). Furthermore, quantitative evaluation of lameness has revealed a high prevalence of potential multi-limb lameness and the confounding effects of compensatory movements (Reed et al., 2020). It is plausible to assume that many of the mysterious lameness cases that ‘cannot be blocked’ are, in fact, compensatory movements by a primary lameness in another limb.

A first potential pitfall of solely objective methods for evaluation of lameness is erroneous marker or sensor placement that would lead to erroneous conclusions as the recorded data track the wrong location. In the Equinosis Q system for example, human error can mainly occur in the placement of the right forelimb sensor and the pelvic sensor. According to Moorman et al. (2017b), rotation of the right forelimb sensor less than 2 cm away from midline did not significantly affect data, but they did not evaluate more severe rotation. According to the manufacturer, rotation of more than 30-45 degrees will reduce the signal, impacting on the accuracy of stride segmentation and derived metrics. Rotation to the back of the pastern or mounting the sensor upside down will even result in classifying the horse lame in the opposite from the true limb (e.g., left fore rather than right fore). For the sacrum, left/right misplacement away from the midline affects the measured asymmetry to a much greater magnitude in comparison to cranial/caudal misplacement: in their study using optical motion capture, Serra Bragan a et al. (2018) reported that each cm of marker placement left/right off the midline leads to an average difference in minimum position of the pelvis of 1.67 mm. Similarly, Moorman et al. (2017b) showed significant effects of a 2-cm sidewards change in the location of the pelvic sensor of the Equinosis Q system. These placement errors result in data that either falsely indicate lameness in a sound horse, soundness in a lame horse or lameness disproportional to what is present. In essence, studies show that if markers or sensors are not placed accurately, results of qualitative gait assessment are inaccurate, too.

A second potential pitfall is bilateral lameness. Obviously, when using head and pelvis displacement asymmetry as a lameness indicator on the straight line, symmetrically bilateral conditions can remain undetected if only looking at the data. Where visual assessment may note a choppy gait or stiffness in movement, the data will only report back on the anatomical landmark which they are attached to. This again underlines the need to use objective gait analysis not as a substitute for visual assessment, but an addition to a holistic approach based on visual observation and measurements. In the case of bilateral lameness, further clinical assessment (lunging, ridden evaluation, diagnostic anesthesia, …) should be used.

A third pitfall is a bias in asymmetry data during lunging and ridden exercise. On the circle, a sound horse presents with movement that is by default asymmetrical (Starke et al., 2012), where the asymmetry depends on circle radius, trotting speed and conformation (Pfau et al., 2012). Care should be taken because circle-induced asymmetry may mask or mimic forelimb or hindlimb lameness (Rhodin et al., 2016), with expected patterns even potentially depending on surface characteristics. For quantitative lameness assessment on the circle, the common approach is currently to compare data for the horse trotting on the left and right rein, trying to keep circle diameter and trotting speed identical between conditions. This area remains subject to further research. Moreover, the presence of a rider, interaction between rider and horse, and rider seating style can also affect vertical movement parameters, with the sitting trot being the least potentially confounding activity and posting commonly causing movement akin to a push-off type lameness in the contralateral limb to which the rider is posting on (Persson-Sjodin et al., 2018).

The final pitfall relates to imperfect classification thresholds and heuristics that must be applied to quantitative methods to make decisions. While decades of biomechanics research allow to approximate reference values for the vertical displacement asymmetry of head and pelvis above which a horse is likely clinically significantly lame, these reference values are not perfect. At present, all indications suggest that for subtle and mild lameness, we are facing an overlap between horses that present with natural and insignificant asymmetry and those that present with asymmetry due to a painful focus in the limb. This results in a ‘signal detection’ problem of finding the best threshold to discriminate between the two. It is unavoidable that around this threshold, some classifications as sound or lame will be incorrect. In addition, the assignment of lameness to left or right limb depends on signal features derived from the recorded data, in the process turning ‘rich’ data into simplified asymmetry measures. How this is done varies between systems. To date, no single metric or approach has proven 100% reliable in indicating the correct limb as lame. Finally, since lame horses present with a range of lameness patterns that affect the derived asymmetry measures and signal shapes, in some instances horses may be misclassified, and for some lameness patterns it even remains unclear how to interpret them. Even in the absence of errors in sensor placement, discrepancies between the visual and quantitative evaluation may arise. On the one hand, it is not surprising to measure subtle asymmetries which are below the visual detection threshold. On the other hand, there is still a lack of knowledge regarding the interpretation of these subtle asymmetries, opening the debate on what degree of asymmetry can be considered normal (van Weeren et al., 2017). In this respect, breed differences should be considered, as significantly larger values of baseline asymmetries have been reported for example in Thoroughbred racehorses (Pfau et al., 2020) and Standardbred trotters (Kallerud et al., 2021). Moreover, several studies on objective evaluation have shown a high prevalence of what would be classified as a mild lameness in horses perceived as sound by their owners (Rhodin et al., 2016, 2017). However, this has also been reported in a study based on comprehensive clinical examination (Dyson and Greve, 2016), and agrees with clinical experience. Therefore, the accurate and objective detection of subtle asymmetries should warrant further clinical examination or at least follow-up, rather than lead to skepticism of the technique. Undiagnosed lameness is a major reason for poor performance, and the increased sensitivity for detecting subtle asymmetries should be used to as a tool to guide further clinical assessment and is very valuable for monitoring horses over time. This may facilitate earlier detection of changes in baselines asymmetry as afforded by solely visual assessment, as shown in an experimental study by McCracken et al. (2012).

With the systems currently available, there is no barrier anymore to clinical everyday use: very little time is required to put the sensors on the horse, measurements can be performed under a variety of clinical conditions and there is no need to focus on a computer screen instead of looking at the patient, so there should be no fear of losing clinical details. As a great benefit, the clinician is provided with data often captured hundred times per second, has access to instant feedback on clinical observations and can track and measure the response to any interventions with increased sensitivity and objectivity. Yet using objective, quantitative tools is not a reason to stop looking at the whole horse and performing a comprehensive clinical evaluation. As with any tool, there definitely is a learning curve in interpreting data, and there is ongoing research to increase our understanding of how we perceive and how we should interpret these movement alterations. With appropriate training in the use of the technology and progressive insights gained by further research in this exciting field, the potential pitfalls or limitations should not discourage clinicians from exploring this application of modern technology. Clinicians should learn to use the technology to their advantage, striving for superior clinical judgement of our equine athletes, as summarized in the statement of Emeritus Professor Derek Knottenbelt: “Technology won't replace vets… but vets who use technology logically and carefully will replace those who don't” (Knottenbelt, 2017).

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