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JOURNAL WATCH: Gait Parameter Variation Using Cameras & Markers – Implications for Q Users

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Study in Review:

Variation in Gait Parameters Used in Objective Lameness Assessment in Sound Horses at the Trot on the Straight Line and the Lunge

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This study looked at the variability of vertical movement of the head, withers, and pelvis as objective lameness measurements in horses perceived not lame by their owners (and evaluated by a veterinarian as less than grade 1/5 lame on the AAEP scale). Variability was assessed between successive collections a few minutes apart, a day apart, and approximately one month apart. This study used optical 3D motion capture (cameras and markers) for direct measurement of vertical position rather than using inertial sensors directly measuring acceleration and then converting to position, but its findings support previous studies on variability of lameness measures using inertial sensors, and reinforces several important points that veterinarians, using either method, should be aware of, as should those using only subjective methods in their lameness examinations.

Parameters measured included:

1. **Range Up and Range Down Difference** (difference in vertical excursion of the head, withers, and midline pelvis, or overall upward or downward movement, between two halves of stride) (Fig 1).

2. **Min Diff and Max Diff** (difference in the two high and low positions of the head, withers, and pelvis, between two halves of stride) (Fig 2). The Q with Lameness Locator measures and reports the equivalent of what this study reports as Min Diff and Max Diff for head and pelvis.

3. **Hip Hike Difference** between swing (difference between upward movement of the tuber coxae during the swing phase of the stride of one hind limb and upward movement of the other tuber coxae during the swing phase of the stride of the other hind limb) and **Hip Hike Stance** (difference between upward movement of the tuber coxae during the stance phase of the stride of one hind limb and upward movement of the other tuber coxae during the stance phase of the other hind limb) (Fig 3).

Fig 1: Range Up and Range Down Difference

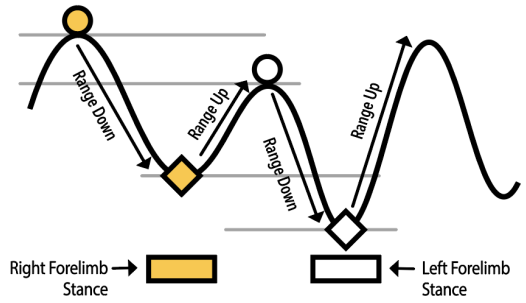


Fig 2: Min Diff and Max Diff

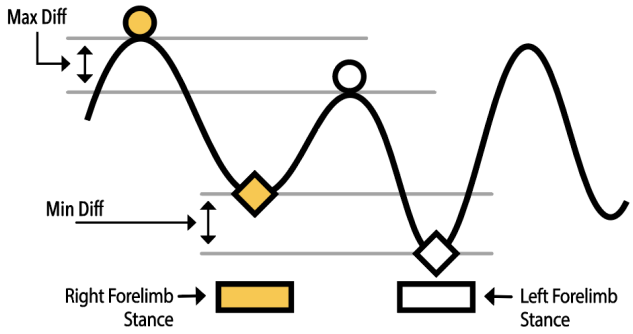
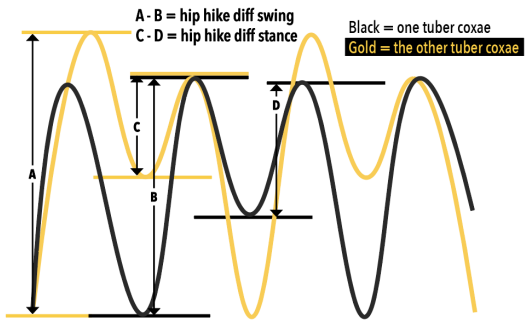


Fig 3: Hip Hike Diff Swing & Stance



Twelve (12) sport horses in regular use were measured for lameness. Five repeat measurements were taken at 5- to 10-minute intervals on successive days (day 1 and day 2), and two repeat measurements taken 28 (in about half of the horses) to 40 (in the other half of the horses) days later. Measurements were performed on hard and soft surface in the straight lines, and while lunging in both directions on soft surface. Horses were warmed up by light exercise prior to beginning daily measurements.

Key findings and how it relates to using the Equinosis Q:

1) Less variation was found in the Min Diff and Max Diff of the withers and pelvis, compared to other measures of the same location, and to all measures of vertical head movement asymmetry.

Note Equinosis uses the terminology Diff Min/Max interchangeably with Min Diff/Max Diff used in this study.

Why, then, does the Equinosis system use the head instead of the withers? Afterall, the head does inherently have more stride-by-stride variability than the torso itself. However, vertical withers movement is less variable primarily because it is damped by the soft tissue sling connecting the forelimb to the torso, which also, unfortunately, also damps the important information content of the signal. In essence, the withers signal is like turning down the volume on a radio. On the other hand, the head signal is an amplification of vertical torso movement. It is the most effective mechanism a horse has for reducing force on a painful limb. It has been shown to be more sensitive than withers movement at the detection of forelimb lameness. The Equinosis system uses head movement to be as sensitive as possible and other methods of noise reduction to mitigate for the higher vertical head movement variability. The head acts like the volume dial on a radio, increasing the intensity of sound (or

signal) so that it can be more easily heard (or measured, or seen).

2) At all locations, the Min Diff and Max Diff variation was lower than Range Up and Range Down (excursion) variation.

3) Less variation was observed with increased repetitions.

It can be postulated that this is due to the horse acclimating to the environment, allowing for more consistent movement and thus more consistent data. It may also be due to additional exercise allowing for the horse's movement (whether symmetric or asymmetric) to stabilize.

This is an important point for veterinarians evaluating lameness with or without objective means. Horses do not always show their true state of lameness (either in presence or amplitude) upon first trot up. Stabilization is an important concept that is underappreciated in subjective evaluation. Allowing the horse to warm up, and repeating measurements improve stabilization of the horse's movement, and increases the clinical relevance/validity of conclusions.

4) Less variation was seen on hard surfaces than soft.

This makes sense that a smooth, flat surface would allow for the least amount of stride-by-stride and trial-by-trial variability, whereas a soft, deformable surface inherently increases variability.

5) Less variation was seen on straight lines versus the lunge.

This has been observed in other studies as well and is due to multiple factors. While the researchers in this study took care to keep the horse at a consistent diameter circle and attempted to lunge the horse at similar speeds, this second element is more difficult to control, and was suggested as a contributing factor for higher variability at the lunge. It was also shown that horse-to-horse variation was greater at the lunge. In terms of factors that may cause asymmetry, the lunge is much more complicated than trotting in a straight line. At the lunge, associations between size of the horse, size of lunging circle, amount of torso lean, speed of movement, and any manner of the horse related to direction or leggedness, are certainly more complicated and likely to be different from horse to horse.

Those using only subjective means of lameness detection should be aware of this increased variability, to avoid misinterpreting certain observations as lameness, or misinterpreting what is perceived as change in lameness, for instance after diagnostic anesthesia. This is also important to users of objective measurement who use the lunge to evaluate horses before and after block or change over time. Veterinarians should be aware that 95% confidence intervals for normal (not lame) lunging have not been determined, and, if they were, would be expected to be larger than straight line evaluation. Therefore, the amount of change from block or treatment that would be considered statistically significant on the circle is presently unknown.

Instead, users of the Equinosis system should be guided in evaluating change in lameness on the lunge by looking more for changes in patterns of asymmetry (i.e. lack of impact or lack of push off), rather than looking for small changes in amplitude of asymmetry, especially when that asymmetry is an expected pattern for the particular surface over which the horse is being lunged. Small changes in asymmetry without a

change in pattern, when that pattern is known to be normal for the particular surface, should be interpreted with caution. The lunging AIDE is a helpful guide for this assessment.

6) More variation was found between than within horses.

This finding is characteristic for just about any biological signal, but it highlights a potential utility of obtaining baseline measurements from an individual horse over time. This could provide the clinician much more useful information on what level of asymmetry, if any, is "typical" for this particular horse, and the ability to track and identify what may be clinically important alterations from that horse's baseline, than attempting clinical judgements on a horse at a single snapshot in time.

7) Between trial measurement variation of "sound" horses was slightly greater than established thresholds of an inertial sensor-based system (i.e. the Equinosis Q with Lameness Locator), with Min Diff and Max Diff Head 13 mm and 12 mm, versus 6 mm, and with Min Diff and Max Diff Pelvis 5 mm and 4 mm, versus 3 mm.

This difference is understandable and likely due to several factors, which include the difference between line-of-site, optical motion capture and inertial sensor-based systems, methods of analysis and data filtering, as well as conditions under which data was collected. Users of the Equinosis Q should remember that its thresholds were established from the 95% confidence intervals when the mean AAEP score of at least 3 experienced practitioners evaluating a horse was a grade 0/5 on the AAEP scale, taking care to collect back-to-back trials with low variability under controlled conditions, on a heterogenous population of horses. There are several reasons why either trial-to-trial variation or thresholds for similar criteria would be different between studies, including the stringency of data collection protocols ensuring low stride-by-stride and trial-by-trial variability, the method of measuring (optical motion capture vs. inertial sensor based), method of analysis and noise filtering technique, number of strides evaluated (this study included a mean of 14 strides where Equinosis thresholds were established on a mean of 25 strides), inclusion or exclusion of outlier strides, and potentially the sample of horses being evaluated.

The back-to-back, trial-to-trial variation of the Equinosis Q system is approximately +/- 6 mm for Diff Max Head and Diff Min Head (or 8.5 mm for head vector sum) and +/- 3 mm for Diff Max Pelvis and Diff Min Pelvis, which are also the same as the established thresholds. What does this mean to the Q user? If back-to-back trial results vary more than these values, then there is a greater chance that this variation is not random, and the horse is in fact changing (i.e. lameness is not stable). However, an important point made in this article is that this trial-to-trial variability could be higher in environments where the data collection is less controlled, in soft or uneven footing, where distractions to the horse are present, or with poor horse handling techniques. ***Repeated measurements and getting increased number of strides reduces both intra-trial (stride-by-stride) and inter-trial (trial-by-trial) variation.

Take away messages from this study that Q users should keep in mind:

1) Best data collection protocols include:

a. Allowing the horse a little bit of warm up exercise before evaluation. This helps relax the horse, acclimate it to potentially unfamiliar surroundings, and stabilize the horse's baseline symmetry (or asymmetry).

   *Exam Efficiency: you could lunge the horse first and collect the data, followed by performing the straight-line evaluation. This allows you to get your baseline lunge evaluation measurements and allow the horse some warm up at the same time. While the effects of warming up can also apply to lunging measurements, collecting more strides (approximately 50 for each direction) can help counteract this.

b. If possible, the horse should be evaluated on a smooth flat surface for straight line evaluations. Uneven or soft surfaces may increase variability.

c. Collect a sufficient number of strides to reduce inherent stride-by-stride variability. 25 strides are recommended for straight line trials using the Equinosis Q, or even more if the horse is misbehaving. More strides should be collected for lunging trials because of the higher variability on a circle. 45-50 strides are generally recommended for lunging trials.

d. Straight line measurements should be repeated for confirmation of stability. Equinosis recommends two straight line trials back-to-back.

   *Measurements should be within +/- 8.5 mm for head vector sum and +/- 3 mm for pelvis Diff Max and Diff Min. If uncertain of stability, collect an additional trial.

2) Lunging is more variable, and several influencing factors should be considered in lunging interpretation, particularly when evaluating change after block or over time.

Summary

While this study looked at variation of horses deemed normal or very subtly asymmetric, the same should be considered for lame horses. Lameness is variable and can change day to day, hour to hour, even minute to minute. Measuring lameness and recognizing the variability that can occur in lameness can help veterinarians avoid the various types of bias we are susceptible to in subjective evaluation. It bears mentioning that lameness is but a clinical sign, not a pathology in and of itself. While it can vary in its presence, amplitude, and consistency, only the veterinarian can determine its source and clinical importance.

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