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Analysis of gait patterns in sound and lame horses

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What is the purpose of equine gait analysis? Is it good for anything practical or is it just something to play with? The goal of this presentation is to show that it is not just a toy and it is not "soft science". It is hard and serious work, and over the years, in many different locations around the world, results of kinematic studies have provided the veterinary profession with useful information and tools for research and clinical practice.

Gait analysis can detect phenomena that cannot be "seen" by the unaided human eye. Most gait analysis techniques sample data at high rate, much higher than the best sampling rate possible with the unaided human eye, even under ideal environmental conditions of visibility. Gait analysis technique provides objective measures that can be defined and explained between colleagues and between mentor and student, allowing standardization of communication and teaching. Standardization and objectivity, if precise and accurate, is always better than lack of standardization and subjectivity.

First let us examine some of the evidence that speaks to the need of an objective method of lameness evaluation. It is based on low agreement between experienced clinicians at detecting mild lameness and the propensity of bias in subjective evaluation.

Evaluation of mild lameness in horses trotting on a treadmill: Agreement by clinicians and interns or residents and correlation of their assessments with kinematic gait analysis. Am J Vet Res 1998. Between observer agreements for detection of lameness; 23% above chance for experienced clinicians, 21% above chance for interns/residents. Between observer agreement for experienced clinicians for a change in lameness only 19% above chance.

Investigations of the reliability of observational gait analysis for the assessment of lameness in horses. Vet Rec 2006. Experienced veterinary evaluators only moderately reliable at assessing lameness severity (56-60% total agreement).

The intra- and inter-assessor reliability of measurement of functional outcome by lameness scoring in horses. Vet J 2006. Inter-assessor agreement barely acceptable (41% above chance). Evidence of bias affecting the interpretation of the results of local anesthetic nerve blocks when assessing lameness in horses. Vet Rec 2006. Veterinarians graded lameness 1 degree lower if they thought a block had been performed.

Repeatability of subjective evaluation of lameness in horses. AJVR 2010. Inter-observer agreement on existence and location of lameness was 50%. Inter-observer agreement on existence of lameness in a given limb was 67% for mild forelimb lameness and 50% for mild hind limb lameness.

This suggests that studying and developing objective methods of lameness evaluation in horses is a worthwhile endeavor. There are 2 approaches to objective lameness evaluation, kinetic methods, most notably the stationary force plate, and kinematic, or the measurement of motion. This presentation will not address kinetic methods, except to say that they are very precise and accurate, but impractical for clinical use. Kinematic technique is typically accomplished with high-speed cameras and markers, but recently body-mounted inertial sensors have been investigated. Kinematic variables generally have higher test-retest variability (i.e. are less repeatable) than force plate variables. Despite this, kinematic gait analysis is generally more intuitive to the veterinary practitioner. It is basically measuring what the practitioner sees anyway, only with greater sensitivity. Computer assistance is used to record, quantify, and then analyze the trajectories of the marked body parts. Because of the desirability to collect multiple contiguous strides most kinematic studies of lameness in horses using cameras and markers are performed when the horse is moving on a treadmill. This is not ideal because the horse moves differently on the treadmill than it does over ground. Recent developments in wireless inertial sensor system design, however, have made it possible to conduct kinematic studies of lameness in horses over ground.

Below is a list of kinematic measures shown by experiment to be reasonable indicators of lameness in horses.

Maximum fetlock extension and maximum coffin joint flexion during the stance phase of the lame limb is decreased compared to the stance phase of the contralateral sound limb.

Carpal extension during stance is reduced in the lame limb but only with moderate to severe lameness.

Stance duration for the lame limb is greater (not less) than for the sound limb in horses with mild to moderate lameness.
Step duration, or the time between pushoff of one limb and impact on the contralateral limb, is shorter between pushoff of the lame and impact of the sound limbs than between pushoff of the sound limb and impact of the lame limbs. Hind limb protraction is usually decreased in most cases of hind limb lameness. Step length, or the distance between placements of opposite limbs, is less between placements of the lame and then sound limbs than between placement of the sound and then lame limb. There is some evidence that vertical movement of the head and torso are the most sensitive kinematic indicators of lameness. Parameters related to vertical movement of the torso most closely follow vertical ground reaction force changes, which are known to be precise and accurate for detection of weight-bearing lameness. In one kinematic study, vertical movement of the torso alone provided greater than 95% correct classification for a 3-class decision (sound, lame in left forelimb, lame in right forelimb). All limb movement parameters and all horizontal and transverse torso movement parameters were less successful at correct classification.

In most case of forelimb lameness in the horse the head falls to a lower height during the stance phase of the sound limb. This is the “down on sound” rule that is frequently cited. However, if the forelimb lameness is most prominent during the acceleration or second half of stance the most prominent head movement asymmetry is in the upward motion of the head. Lameness in the second half of stance causes the head to rise to a higher height at or after the end of the stance phase of the lame limb. There is evidence to suggest that the relationship between low and high heights of the head is determined by the timing of forelimb lameness, i.e. is the lameness most prominent at impact, or in the first half of stance, or during pushoff, in the second half of stance.

The majority of forelimb lameness conditions are “impact” type, i.e. they are most prominent in the first half of stance. There are 2 methods of using pelvic movement to measure hind limb lameness, evaluating whole vertical pelvic movement and evaluating pelvic rotation.

**VERTICAL PELVIC MOVEMENT METHOD**

The whole pelvis falls to a lower height during the stance phase of the lame limb and/or rises to a lower height after pushoff of the lame limb. There is some evidence that the relationship between lowest and highest whole pelvic position is determined by the timing of hind limb lameness, i.e. is the lameness most prominent at impact, or in the first half of hind limb stance, or during pushoff, in the second half of stance. More hind limb lameness conditions cause “pushoff” than “impact” lameness, i.e. most hind limb lameness conditions are most prominent in the second half of stance.

**PELVIC ROTATION METHOD**

The hemi-pelvis on the lame hind limb side moves up or down (or both) more than on the sound hind limb side. If the hind limb lameness is most prominent during the first half of stance the hemi-pelvis on the lame hind limb side moves up more (a “hip hike”) than the hemi-pelvis on the opposite (sound) side right before the beginning of stance. If the hind limb lameness is most prominent during the second half of stance the hemi-pelvis on the lame hind limb side moves down more (a “hip dip”) than the hemi-pelvis on the opposite (sound) side right after the end of stance. The pelvic rotation method is easier for most veterinarians to see, however, it is speculated that this technique may be faulty in horses with asymmetric pelvis and is less sensitive to change when observing horses before and after block.