Proceedings of the American Association of Equine Practitioners

Focus Meeting on the Sport Horse
Louisville, KY, USA - July 20 – 22, 2014

Next Meetings:
Focus on Ambulatory - Jul. 26-28, 2015
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Biomechanics of Lameness

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Take Home Message—Equine locomotion involves consistent patterns of limb movements that change in predictable ways when the horse is lame. The lame horse decreases the peak vertical force on the lame limb by moving with a flatter trajectory (less suspension), spreading the force over a longer period of time and redistributing the weight among the lame and compensating limbs. Inertial sensor systems are proving useful in monitoring lameness and also in understanding the capabilities and limitations of the clinician's eye.

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I. LOCOMOTION AT TROT

Locomotion is the act of moving the body by generating ground reaction forces (GRF) to support and transport the center of mass. By transitioning between gaits, horses can move at a wide range of speeds. This talk will focus on the trot which is an important gait both for judging the quality of a horse’s movement and for detecting asymmetries indicative of lameness.

The trot is a symmetrical gait implying equal steps and forces in the left and right limbs which makes it suitable for detecting asymmetries associated with lameness. However, it is normal for there to be some asymmetry even in sound horses due to sidedness that is similar to handedness in people. The majority of horses displace the haunches to the left, are reluctant to bend the body to the right, and take more contact on the left rein.

Good training should make the horse more ambidextrous. One of the challenges for researchers is to determine threshold levels for distinguishing asymmetry from lameness.

II. GAIT ADAPTATIONS IN LAMENESS

Lame horses decrease structural stress by using kinematic adaptations that reduce peak vertical force in the painful limb. Since forces are not visible to the human eye, it is the kinematic changes that form the basis of visual lameness detection and diagnosis.

A well-defined suspension with a visible “springiness” in the stride is an indicator of locomotor health. The first sign of mild lameness is often deterioration in quality of movement as the horse avoids generating the large vertical forces required for a well-defined suspension; consequently, the horse appears to creep rather than bounce over the ground. As the degree of lameness becomes more severe, the horse further reduces or eliminates the suspension phase that follows lame limb stance. This avoids the need to push against the ground to raise the body; instead, the weight rolls forward over the lame limb onto the compensating diagonal.

A mildly lame horse will choose to trot more slowly if given the option but, if forced to maintain trotting speed, stride frequency and stance duration will increase as a means of spreading the total vertical impulse over a longer period of time. This allows the impulse that is necessary to maintain forward motion to be generated with a lower peak vertical force. In more severe lameness cases, responsibility for load-bearing and generation of propulsion are redistributed from the affected limb to the compensating limbs so that total vertical impulse summed over all four limbs is maintained.

Within the diagonal pairs, lame horses most often shift the weight toward the hind limb of the lame diagonal and toward the forelimb in the compensating diagonal.

Since fetlock extension during stance is proportional to peak vertical force, reduced fetlock extension may be evident in the lame limb compared with the contralateral (compensating) limb.

The head nod is a dynamic mechanism for shifting weight cranioceudally. The neck descends with the trunk during the diagonal stance phase under control of the dorsal cervical musculature. In forelimb lameness, sinking of the head and neck is reduced or abolished during the lame diagonal stance phase and increased during the compensating diagonal stance phase. As the compensating diagonal pushes off, the head and neck swing upward and increase the downward force of the hoof against the ground. This helps lift the trunk by providing an increased vertical GRF and by creating a torque around the cervicothoracic junction.

In a research environment motion analysis, systems and force plates have been used to describe and analyze equine gaits and the effects of lameness. In the field, inertial sensor systems (ISS) based on the use of accelerometers, gyroscopes and...
magnetometers are more practical for detecting and monitoring lameness. These are marketed as the Lameness Locator®, Equigait® and Equimetrix®. Their use is based on the symmetrical vertical movement of the head, withers and croup during the left and right diagonal stance phases in sound horses. The Equigait system also monitors movements and asymmetries of the tubera coxae. The trunk descends to its lowest point in mid stance and rises to its highest point around the time of lift off. Lame horses control the trunk descent in order to reduce loading of the lame limb and, as a result, trunk movements become asymmetrical on the two diagonals. The poll, withers and croup are supported in a higher position at the start of the lame diagonal stance phase to prevent the trunk gathering downward momentum before the lame limb contacts the ground. This is accomplished by having the lame fore or hind limb contact the ground with a more vertical orientation, which is visible as a “reduced cranial phase”, and is a common observation in many types of lameness. Descent of the trunk during the lame stance phase is reduced in proportion to lameness severity. Inertial-based systems detect the resulting asymmetries in the vertical movement of the horse’s midline and the software indicates which limb is lame and to what degree. These inertial-based systems are proving useful for quantifying lameness and monitoring changes in response to the administration of nerve/joint blocks or therapies.

III. LAMENESS ASSESSMENT

Veterinary students are taught the basic principles of lameness evaluation and it has been shown that the use of video tutorials including audio, slow motion and freeze frame improves learning and retention of lameness detection skills. It has been suggested that a lower limit for recognition of asymmetry by the human eye is about 25% with hind limb lameness being a more difficult diagnostic challenge than forelimb lameness. Consistency in lameness scoring improves with experience of the clinician and severity of lameness. Reliability of lameness grading is better within an individual clinician than between clinicians with inter-observer agreement being acceptable for moderate to severe lameness but poor for mild lameness. After diagnostic blocks were performed evaluators showed a bias toward judging an improvement in lameness even when none was present.

The horse’s trotting speed affects the clinician’s diagnostic ability. For horses trotting on the straight, objective measurements show that the degree of lameness does not change as speed increases but the clinician’s subjective lameness score decreases. This is likely a consequence of limits to the temporal resolution of the human eye. For horses trotting on a circle, objective measurements show that the severity of lameness increases with speed but the clinical impression is that lameness grade does not change. The likely explanation is that a real increase in severity is balanced by a reduced perceptual ability at faster speeds. Based on these findings it is recommended that horses be evaluated at a slow trot, especially those with subtle lameness and that care is taken to use a consistent evaluation speed.

During lunging, speed and circle diameter affect locomotor symmetry. Small circle diameter and/or fast trotting speeds eventually result in an asymmetric motion pattern that simulates lameness of the inside limbs even in sound horses.

Flexion tests of the proximal joints of the hind limb change the motion symmetry even in sound horses; upward motion of the croup decreases following mid stance of the flexed hind limb and increases following mid stance of the nonflexed limb. This results in a ‘hip hike’ of the flexed limb and exacerbates a subtle asymmetry that may then exceed the threshold for detection by the clinician. The response to flexion is, however, highly variable between horses and decreases with the distance trotted.

References and Footnotes


a. Lameness Locator®, Equinosis, LLC, Columbia, MO
c. Equimetrix, Centaure Metrix, Evry, France.