# How to enhance your sports medicine practice through the use of telemedical (remote) lameness observation

**G. Robert Grisel, DVM**

The Atlanta Equine Clinic, 1665 Ward Road, Hoschton, GA 30548;
bobgrisel@atlantaequine.com

## 1. Introduction

For the better part of veterinary medical history, clinical examination was the primary method used to diagnose lameness in the horse. Through meticulous inspection and a methodical approach, the veterinarian would formulate a visual impression of the horse's movement for the purpose of discerning clinical significance(s). Individual gait characteristics were identified and subsequently "decoded", using previous correlations and experience obtained by the examining veterinarian. This approach to evaluation was more representative of "art" than medicine, but often allowed the practitioner to accurately interpret the relationship between specific gait abnormalities and probable sources of lameness. Several pioneers in the field of equine sports medicine were known for their ability to "diagnose lameness at a glance".

Our desire to extract dynamic intelligence relating to the horse's gait prompted the use of cinematographic motion analysis over 40 years ago.[1-4] More recent telemetric research has been conducted under environmental control with the intention of formulating objective "rules" for the quantification of lameness. Through kinematic and kinetic analysis, parameters such as stride length, stride height, stance phase duration, head excursion and weight distribution are assessed.[5] Although the "code" of equine locomotion is gradually being deciphered via these studies, the majority of this knowledge has yet to find regular application with regard to veterinary observation of movement in the field.

Consequently, most private practitioners are still relying on their own visual "impression" of the lame horse during clinical examination. Although this aspect of the examination has been less emphasized pursuant to the veritable explosion of newer diagnostic and imaging modalities, it remains an essential component of thorough investigation.

Fortunately, the advent of new information technologies and readily-accessible motion analysis software enables the modern equine veterinarian to visually observe lameness at a distance. This form of medicine, known as telemedicine, is currently provided to human medical patients, formula-one race car drivers and astronauts (among others).[6-10]

Telemedicine presents a variety of advantages to the equine practitioner. These include:

- Elimination of distance barriers
- Reduction in overall veterinary workload
- Reduction in the need for accessory personnel
- Elimination of physical risk (danger) to veterinary personnel
- Reduction in veterinary evaluation time and expense
- Reduction in reporting turnaround time
- Synchronized networking between caretakers (owner, trainer, farrier, veterinarian, etc.)
- Increased accessibility to a centralized pool of medical expertise

The objective of this investigation was to determine the overall value of remote lameness observation within one equine practice[a].

## 2. Materials and Methods

Video clips of 319 horses with a presenting complaint of decreased performance were remotely reviewed by one veterinarian between January 2011 and January 2013. In all cases cited in this study, lameness was observed telemedically using motion analysis software[b] prior to hands-on veterinary examination or diagnosis.

In each instance, probable sources of lameness were surmised and recorded by the telemedical examiner. Postulations were derived from a combination of digital examination findings and past experience. Due to the examiner's inability to differentiate between certain regionally-based problems (such as a severe foot bruise, early foot abscess, or chronic P3 fracture), more than one possible diagnosis within a specific anatomic region (e.g. below the level of the fetlock) were listed within a single classification (see below).

Specific diagnoses were subsequently made and confirmed through local (on-site) examination by a veterinarian using diagnostic modalities such as anamnesis, palpation, active flexion testing, local perineural or intraarticular anesthesia and imaging (radiographic, ultrasonographic, thermographic and/or scintigraphic). In 88 of the cases, follow-up (hands-on) evaluation was performed by the remote examining veterinarian.

### Acquisition of Video Footage

Footage was obtained by an individual (owner, trainer or local veterinarian in the physical presence of the horse. Footage in standard definition and either .avi or .mov formats was considered preferable, although software allowed for various format conversion. Camera motion during filming was restricted to a horizontal plane; vertical movement, zooming and/or panning was discouraged as this made subtle gait abnormalities more difficult to discern. When possible, a consistent distance between the camera and subject was also maintained.

The following footage was requested:

- With the horse standing squarely on a level surface: dorsal views of the thoracic feet and limbs together, plantar views of the pelvic feet and limbs together, lateral views of each thoracic and pelvic foot separately and right and left lateral views of the entire animal.
- With the horse moving on a hard (e.g. asphalt) surface: cranial and lateral views of the horse walking and trotting in a straight line on a loose lead.
- With the horse on a soft (e.g. arena) surface: lateral views of the horse at the walk, trot and canter on the lunge and under saddle.
- In some cases, history dictated that additional footage be procured.

### Submission of Video Footage

Footage was usually shared through a free file hosting service[c] that offers synchronization of large files between users. A folder containing video footage was shared between the client, farrier, attending veterinarians and other related parties.

### Loading of Footage into Motion Analysis Software

Images within shared folders were accessed through a file management feature built into the software. Specified photographs and video clips were uploaded into a viewing panel for evaluation.

### Digital Evaluation of Video Footage

Once uploaded, pertinent image(s) were viewed within the motion analysis application. The software offered a variety of tools that allowed for more thorough evaluation of footage and objectification of observations when possible (Fig. 1).


LIST OF TOOLS
- Angle Measurement
- Clip Speed Adjustment
- Deinterlacing Function
- Distance Measurement
- Dynamic Distance (Speed) Measurement
- Dynamic Tracking
- Image Overlay Function
- Stopwatch

**Fig. 1. Digital Evaluation Tools**

The remote examiner analyzed the footage with the intention of answering a series of questions:

- Which limb or limbs are affected?
- What is the grade[d] of lameness?
- What is the nature of the lameness?
- At which gait(s) is lameness observed?
- How does the lameness change with regard to surface?
- How does the lameness change with regard to direction?
- Are there any distinguishable traits to the lameness?

## Classification and Categorization of Video Footage

Video clips were classified based on visible lameness characteristics and subsequently categorized into groups of similar findings. Unique gait characteristics were noted wherever depicted.

## Electronic Record Creation

Observation findings were documented.  Segments of video footage, photographs, diagrams and verbal commentary were often appended to the patient's record, which was created within the software application.

## Sharing of Evaluation Results

A copy of the record was published to the web using the file hosting service.  A link to the record was concurrently created and sent to authorized parties to allow for online viewing and/or downloading.

## 3. Results

Telemedical observation findings of 319 horses were classified based on gait characteristics (Table 1). Independent thoracic and pelvic asymmetries were observed in 36 of the horses; these were evaluated and classified as separate (distinct) deficits.

**Table 1. Classification of Gait Characteristics**

| Classification | Limbs Affected | Laterality of Lameness | Nature of Lameness* | Gaits Most Affected | Surface Influence | Directional Influence | Unique Traits | # Deficits Observed |
|---|---|---|---|---|---|---|---|---|
| A | Thoracic | Unilateral | WB | At Rest, Walk, Trot | Worse on Hard | Worse to Inside | Significant head excursion, Asymmetrically lands or bears weight on foot | 31 |
| B | Thoracic | Bilateral | WB | Walk, Trot | Worse on Hard | Worse to Inside | Significant head excursion, Premature cranial phase to stride, Cranial phase of stride is longer than caudal phase, Lands toe-first,Tripping, Pointing | 13 |
| C | Thoracic | Bilateral | WB | At Rest, Walk, Trot | Worse on Hard | Worse to Inside | Premature cranial phase to stride, Cranial phase of stride is longer than caudal phase, Lands heel-first, Pointing, Treading | 4 |
| D | Thoracic | Unilateral or Bilateral | WB | Trot | Worse on Hard | Worse to Outside | --- | 33 |
| E | Thoracic | Unilateral | WB and NWB | Trot | Worse on Soft | --- | Shortened stride length, Foot lands toe-first | 8 |
| F | Thoracic | Unilateral or Bilateral | WB and NWB | Trot | --- | Worse to Outside | Delayed cranial phase to stride, Shortened stride length | 13 |
| G | Thoracic | Unilateral or Bilateral | NWB | Walk, Trot | Worse on Soft | Worse to Outside | Delayed cranial phase to stride, Shortened stride length, Hypometric | 9 |
| H | Thoracic | Unilateral | WB and NWB | Walk, Trot | --- | --- | Caudal phase of stride is longer than cranial phase | 1 |
| I | Thoracic | Unilateral | WB and NWB | Walk | --- | --- | Dropped elbow, Limb is held underneath body | 1 |
| J | Thoracic | Unilateral | NWB | Trot | Worse on Soft | Worse to Outside | Significant head swing, Delayed cranial phase to stride, Shortened stride length, Hypometric | 4 |
| K | Thoracic | Unilateral | NWB | Trot | --- | Worse to Outside | Head swing, Delayed cranial phase to stride, Shortened stride length, Hypometric, Holds neck lower-than-normal | 3 |
| L | Pelvic | Unilateral | WB | Walk, Trot | Worse on Hard | --- | --- | 1 |
| M | Pelvic | Unilateral | WB | Walk, Trot | Worse on Hard | Worse to Inside | Sticks toe into footing | 1 |
| N | Pelvic | Bilateral | WB | At Rest, Walk, Trot | Worse on Hard | --- | Pelvic limbs camped underneath body, Cranial phase of stride is longer than caudal phase, Treading | 1 |
| O | Pelvic | Unilateral | WB and NWB | Walk, Trot | Worse on Soft | Worse to Outside | Sticks toe into footing | 14 |
| P | Pelvic | Unilateral or Bilateral | WB | Walk, Trot | --- | Worse to Inside | Limb adduction during cranial phase of stride followed by sudden abduction, Lateral rotation of the tarsi under weightbearing load, Excessive varus deformation (bowing) of tarsi under weightbearing load | 120 |
| Q | Pelvic | Unilateral | WB and NWB | Walk, Trot, Canter | Worse on Soft | --- | Shortened stride length, Hypometric, Sticks toe into footing | 11 |
| R | Pelvic | Unilateral | NWB | Trot, Canter | Worse on Soft | Worse to Outside | Delayed cranial phase to stride, Shortened stride length, Hypometric, Sticks toe into footing | 36 |
| S | Pelvic | Bilateral | NWB | Canter, Canter Depart, Downward Transitions | --- | Worse to Outside | Delayed cranial phase to stride, Shortened stride length, Hypometric, Sticks toe into footing | 16 |
| T | Pelvic | Bilateral | NWB | Canter, Canter Depart, Downward Transitions | --- | --- | Fixed extension of the hind limb, Involuntary and sudden hyperflexion occurs at initiation of cranial phase of stride | 16 |
| U | Pelvic | Unilateral | WB | Walk, Trot, Canter | --- | --- | External rotation of the limb (hock-in and toe-out), Cranial phase of stride is longer than caudal phase | 13 |
| V | Pelvic | Unilateral | NWB | Walk | --- | --- | Stifle flexes during cranial phase of stride but hock remains in extension | 1 |
| W | Pelvic | Unilateral or Bilateral | NWB | At Rest, During Backing | --- | --- | Prolonged hyperflexion of the limb with concurrent tail raising | 1 |
| X | Pelvic | Unilateral | NWB | Walk | --- | --- | Shorten cranial phase to stride, Goose step | 3 |
| Y | --- | --- | --- | --- | --- | --- | LAMENESS NOT DETECTED | 1 |
| | | | | | | | | |
| | * Weightbearing (WB) and/ or Nonweightbearing (NWB) | | | | | | TOTAL DEFICITS OBSERVED | 355 |

Differential diagnoses were postulated based on the observer's visual (impressionistic) classification of gait. Comparison of telemedical (remote) and confirmed (hands-on) diagnoses was then performed in an attempt to establish potential correlation (Table 2).

**Table 2. Categorization of Lameness**

| Classification | # Deficits Observed | Remote (Regional) Diagnosis | On-Site Diagnosis | Remote Observations Validated | Remote Observations Invalidated | % Validated |
|---|---|---|---|---|---|---|
| A | 31 | Foot Abscess<br>Foot Bruise<br>P3 Fracture | Navicular inflammation=1<br>Foot abscess=18<br>Foot bruise=4<br>P3 fracture=1<br>Laminitis=1<br>DIP joint=6 | 23 | 8 | 74.19 |
| B | 13 | Thoracic navicular inflammation | Navicular inflammation=8<br>Foot bruise=1<br>Laminitis=1<br>DIP joint=4 | 8 | 5 | 61.54 |
| C | 4 | Thoracic Laminitis | Navicular inflammation=2<br>Laminitis=2 | 2 | 2 | 50 |
| D | 33 | Medial foot Abscess<br>Medial Foot Bruise<br>DIP Joint | Medial foot abscess=5<br>Medial foot bruise=7<br>Medial hoof wall crack=2<br>Laceration/ trauma of medial heel bulb=1<br>Medial heel quarter Text keratoma=1<br>DIP joint=17 | 33 | 0 | 100 |
| E | 8 | Flexor tendons<br>Suspensory Ligament<br>Palmar Digital Sheath | Flexor tendon(s)=4<br>Suspensory Desmitis=2<br>Palmar digital tenosynovitis=2 | 8 | 0 | 100 |
| F | 13 | Fetlock joint | Fetlock=9<br>Radiocarpal joint=3<br>Flexor tendons=1 | 9 | 4 | 69.23 |
| G | 9 | Carpus | Fetlock=3<br>Radiocarpal joint=1<br>Midcarpal joint=2<br>Both radiocarpal/midcarpal joints=3 | 6 | 3 | 66.67 |
| H | 1 | Elbow joint<br>Radial Nerve Paresis | Elbow joint=1 | 1 | 0 | 100 |
| I | 1 | Olecranon Fracture<br>Radial Nerve Paralysis | Radial nerve paresis=1 | 0 | 1 | 0 |
| J | 4 | Bicipital bursitis | Bicipital bursitis=3<br>C5–6 arthrosis=1 | 3 | 1 | 75 |
| K | 3 | Caudal Cervical Area | Bicipital bursitis=1<br>C5–6 arthrosis=1<br>C6–7 arthrosis=1 | 2 | 1 | 66.67 |
| L | 1 | Foot Abscess<br>Foot Bruise<br>P3 Fracture | Foot bruise=1 | 1 | 0 | 100 |
| M | 1 | Heel Abscess<br>Heel Bruise | Medial heel bulb bruise=1 | 1 | 0 | 100 |
| N | 1 | Pelvic Laminitis | Pelvic laminitis=1 | 1 | 0 | 100 |
| O | 14 | Fetlock joint<br>Flexor tendons<br>Suspensory Ligament<br>Plantar Digital Sheath | Flexor tendon(s)=2<br>Palmar digital tenosynovitis=4<br>Femoropatellar joint=6<br>Femorotibial joint=2 | 6 | 8 | 42.86 |
| P | 120 | Distal Tarsal joints | Distal tarsitis=120 | 120 | 0 | 0 |
| Q | 11 | Femorotibial joint | Femorotibial joint=6<br>Femoropatellar joint=5 | 6 | 5 | 54.55 |
| R | 36 | Femoropatellar joint | Plantar digital tenosynovitis=2<br>Suspensory Desmitis=2<br>Femoropatellar joint=24<br>Proximal patellar hesitation=8 | 24 | 12 | 66.67 |
| S | 16 | Proximal Patellar Hesitation | Femoropatellar joint=5<br>Proximal patellar hesitation=11 | 11 | 5 | 68.75 |
| T | 16 | Upward Patellar Fixation | Upward Patellar Fixation=16 | 16 | 0 | 100 |
| U | 13 | Pelvis<br>Coxofemoral joint<br>Greater trochanteric Bursa | Distal tarsitis=11<br>Coxofemoral joint=1<br>Greater trochanteric bursitis=1 | 2 | 11 | 15.38 |
| V | 1 | Peroneus Tertius Rupture | Rupture of the peroneus tertius tendon=1 | 1 | 0 | 100 |
| W | 1 | Shivers | Shivers=1 | 1 | 0 | 100 |
| X | 3 | Pelvic Fibrotic Myopathy | Semitendinosus fibrotic myopathy=2<br>Semimembranosus/ Gracilis fibrotic myopathy=1 | 3 | 0 | 100 |
| Y | 1 | LAMENESS NOT DETECTED | CI dorsal osteitis=1 | 0 | 1 | 0 |
| TOTALS | 355 | | | 288/355 | 67/355 | 81.13 |

## 4. Discussion

Although the visual diagnostic ability of the author certainly leaves "room for improvement" with regard to accuracy and specificity, this study suggests that considerable value can be afforded to remote digital observation of the lame horse. Diagnoses supported the examiner's observations in 80% of cases assessed within this investigation. Based on previous experience, the examiner was able to assign a number of visible aberrations in gait to consistent sources of lameness with moderate precision. Tools built into the motion analysis software facilitated differentiation of discrete gait deficits when necessary and possible. Subsequent classification and categorization of abnormal motion patterns assisted in the establishment of a cursory relationship between personal visual impression and clinically-significant pathology.

The fact that similar gait deficits exist for a variety of problems makes remote observation an impractical strategy for reaching or confirming a diagnosis of lameness, except in horses exhibiting a single pathognomonic abnormality (such as obvious goose-stepping in the pelvic limb). The ability to differentiate between multiple problems within the foot, for example, were not possible when based solely on the author's visual impression(s). There was a clear aptitude for distinguishing between problems in the foot and those above the fetlock joint, however. Although relatively nonspecific, this form of "regionalized" information has proven to be useful during preemptive screening prior to hands-on examination, post-treatment follow-up assessment and instant sharing of opinions between professionals affiliated with this practice.

In addition to providing a means by which to easily assess a horse during movement, telemedical availability allowed this examiner to accumulate a large number of cases within a comparably short period of time. This was attributed to the relative lack of time, distance and financial restrictions associated with this modality. A setting in which a single examiner can evaluate a large number of subjects has been suggested to be a crucial part of refining one's subjective diagnostic accuracy.[11] Telemedical motion analysis, therefore, may also provide a foundation on which the equine veterinarian can develop, modify, refine and translate visual impressions into meaningful clinical information. Once interpretative "rules" have been established for an observer, a more educated approach to visual evaluation (both from local and remote standpoints) is possible.

Since the recognition of gait characteristics is typically based on individual interpretation rather than objective markers, it is unrealistic to surmise that all variations in movement would be identically perceived between examiners. Lameness grade quantification among veterinary examiners has shown to be unreliable for the same reason.[12] Lameness classification and categorization designations cited in this paper were specific to the author, as was the ability to recognize individual gait aberrations. It is probable that another practitioner would use a discrete and personalized set of criteria with which to develop an overall impression, or that he/she might interpret identical information differently. Regardless of the impressionistic methodology, however, we might expect that multiple experienced observers would eventually make comparable deductions with regard to differential diagnoses. Future studies to determine the diagnostic consistency among a group of veterinarians using this technique are warranted.

## 5. Conclusion

The dramatic increase in evaluation efficiency afforded by telemedical observation allows the equine veterinarian to provide an attentive, proactive approach to managing and preventing lameness. Progress can be assessed on a regular basis with very little investment of time and money on behalf of the practitioner. This translates into a better overall service to the client. Although telemedical assessment comprises only one facet of comprehensive lameness investigation, it's implementation can enhance the diagnostic proficiency of the equine performance veterinarian.

## References and Footnotes


1. Tabin VI. Analysis of motion in the ulnar joint of some animals by high-speed cinematography. *Arkh Anat Gistol Embriol* 1965;49:46-51.

2. Fredricson I, Drevemo S. A new method of investigating equine locomotion. *Equine Vet J* 1971;3:137-140.

3. Fredricson I, Drevemo S, Moen K, et al. A method of three-dimensional analysis of kinematics and co-ordination of equine extremity joints. A photogrammetric approach applying high-speed cinematography. *Acta Vet Scand Suppl* 1972;37:1-133.

4. Bayer A. Motion analysis in trotting horses using ungulography. *Zentralbl Veterinarmed* 1973;20:209-21.

5. Hobbs SJ, Levine D, Richards J, et al. Motion analysis and its use in equine practice and research. *Wiener Tierarztliche Monatsschrift* 2010;97:55-64.

6. Field MJ, Grigsby J. Telemedicine and remote patient monitoring. *JAMA* 2002;288:423-425.

7. Katsis CD, Ganiatsas G, Fotiadis DI. An integrated telemedicine platform for the assessment of affective physiological states. *Diagn Pathol* 2006;1:16.

8. Bashshur R, Lovett J. Assessment of telemedicine: Results of the initial experience. *Aviat Space Environ Med* 1977;48:65-70.

9. Doarn CR, Nicogossian AE, Merrell RC. Applications of telemedicine in the United States space program. *Telemedicine Journal* 1998;4:19-30.

10 .Nicogossian AE, Pober DF, Roy SA. Evolution of telemedicine in the space program and earth applications. *Telemedicine Journal and e-Health* 2001;7:1-15.

11. Keegan KG, Columbia MO. Objective measures of lameness evaluation, in *Proceedings*. ACVS Veterinary Symposium 2012;127-131.

12. Dyson, S. Can lameness be graded reliably? *Equine Vet J* 2011;43:379-382.


[a] The Atlanta Equine Clinic 1665 Ward Road Hoschton, GA 30548
[b] Equine Tec Video Analysis Software P.O. Box 1133 Monroe, GA 30655
[c] Dropbox®, Inc. 185 Berry Street, San Francisco, CA 94107
[d] Guide to veterinary services for horse shows, ed 7. Lexington, KY. American Association of Equine Practitioners, 1999.