EQUINOSIS®

LAMENESS LOCATOR®

User Manual

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BACKGROUND

Lameness Locator® is a wireless inertial sensor-based, motion analysis system specifically designed to objectively detect and evaluate lameness in horses. Inertial sensors are non-invasively attached to the head (accelerometer), right distal forelimb (gyroscope) and pelvis (accelerometer). Movement data is wirelessly transmitted in real time to a tablet PC, where a series of motion analysis algorithms are implemented to analyze the collected motion. These positions and types of motion sensors were chosen only after completion of an in-depth search for the most sensitive motion positions and parameters for determination of lameness in horses. Vertical motion of the torso was found to be the parameter that most closely mimics vertical ground reaction forces on the limbs, which is a direct measure of lameness in horses.

The motion analysis algorithms of Lameness Locator® do not simply track and display trajectories of the instrumented body positions and report these to the user. The algorithms developed for Lameness Locator® were specifically designed to analyze motion related to lameness in the horse. They are an adaptation of fault detection engineering where lameness (the fault) perturbs expected motion in a sound horse. Lameness Locator® reports which limb or limbs are involved in the lameness, the intensity of lameness in each limb, and the interval during the stride cycle at which lameness severity is greatest, helping to differentiate impact-type or beginning of stance lameness from push-off type or end of stance lameness. The equine veterinarian, with existing knowledge of anatomy and biomechanics, can use this information to help further localize the foci of lameness within the limb.

The sensors of Lameness Locator®, because they sample motion at 200 times per second, are more sensitive than the human eye, which samples at only about 20-25 times per second. Small differences in motion amplitude of the torso caused by impact and push off of the right and left halves of the body can be detected by the inertial sensors that would not be detected with the unaided human eye. This higher sensitivity will also detect compensatory movement patterns in the opposite half of the body that are normally not seen or appreciated subjectively. The veterinarian can use the whole torso movement picture, both primary and compensatory patterns, to help objectively detect and evaluate lameness in the horse.

Work on the concept of Lameness Locator® began at the University of Missouri in the early 1990s. The motion analysis algorithms were developed over several years after investigating the characteristic motion in lame and sound horses using naturally-occurring and induced lameness models, high-speed cameras and the equine treadmill. Adaptation of these algorithms to an inertial sensor based system began in the year 2000. Equinosis LLC, a faculty startup company funded by local angel investors was formed in 2008. Further support of Equinosis for additional research and development is provided by the National Science Foundation Small Business Technology Transfer Research grant program.

THE SENSORS

Each set of Lameness Locator® sensors consists of head and pelvic accelerometers and a right forelimb (RF) gyroscope. For ease of use in the clinical arena, some users may prefer to have multiple sets of sensors. Each set will have color coded labels (white, green and/or brown) for identification.

The Head Sensor

The sensing unit in the head sensor is a uni-axis (vertical) accelerometer. The head sensor is labeled HEAD, with a serial number. The drawing of the horse head on the label is oriented to facilitate proper directional placement of the sensor on the horse. There is a small, rectangular 3M Dual Lock tape patch attached to its *non-labeled* side.

The Right Forelimb Sensor

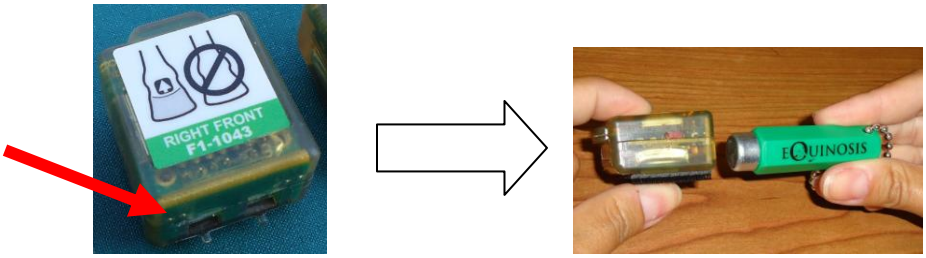
The sensing unit in the right forelimb sensor is a uni-axial gyroscope. The right forelimb pastern sensor is labeled RIGHT FRONT with a serial number. The drawing on the label indicates that the sensor should only be applied to the right front limb, oriented to facilitate proper directional placement on the horse. There is a small, rectangular 3M Dual Lock tape patch attached to its *non-labeled* side.

The Pelvic Sensor

The sensing unit in the pelvic sensor is a uni-axial (vertical) accelerometer. The pelvic sensor is labeled PELVIS with a serial number. The drawing of the pelvis on the label is labeled to facilitate proper directional placement of the sensor on the horse. There is a small, rectangular 3M Dual Lock tape patch attached to its *non-labeled* side.

Turning the Sensors On and Off

The sensor on/off switch is magnetic and embedded within the sensor casing. Turning the sensors on and off is performed with a magnet, which is supplied with the system. The magnetic switch is located near the left charging plate on the short end of the sensor.



To turn the sensor on, place a magnet adjacent to the end of the sensor near the left charging plate. A GREEN LED will turn on (visible from the side of the sensor) and, after about 3-4 seconds, begin blinking rapidly. Move the magnet away from the sensor after the sensor LED begins blinking. The LED will begin to blink more slowly, about two to three times per second. The sensor is now turned ON. Repeat with the other two sensors and they are then ready for use. If the LED begins blinking but quickly turns off, the sensor battery charge is low and should be re-charged. If the sensor will not turn on, the batteries are completely discharged. Recharge the sensor by inserting into the Lameness Locator® charging station.

Green LED will illuminate here

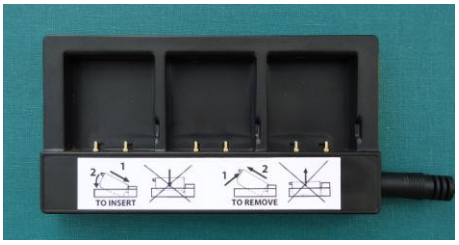
Each Lameness Locator® sensor is designed with an automatic "power-off" feature. The sensor will automatically shut off if not connected to the Lameness Locator® software after 20-30 minutes, depending on existing battery charge. This functionality is designed to spare battery power if the user inadvertently forgets to shut off the sensors after use.

To turn the sensor off, hold the magnet at the same previously-described position for 3-4 seconds until the LED stops blinking. Note: the sensors cannot be turned off unless they are disconnected from the LL software (refer to software navigation).

Charging the Sensor Batteries

Each sensor is equipped with an on-board, 4.5 volt, rechargeable, lithium polymer battery. The sensors are recharged by placing within the 3-port battery charging station supplied with the Lameness Locator® system (see below). *DO NOT TRY TO CHARGE UP THE SENSORS WITH ANY OTHER BATTERY CHARGER.* **Your Lameness Locator® sensors should be fully charged upon receipt, so you should not need to charge them prior to first use.**

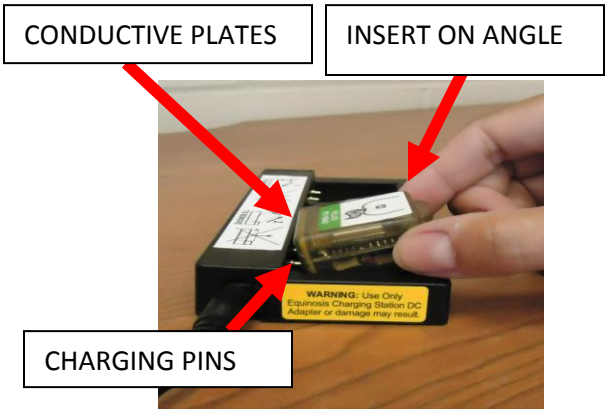
Inserting the Sensors to the Battery Charger



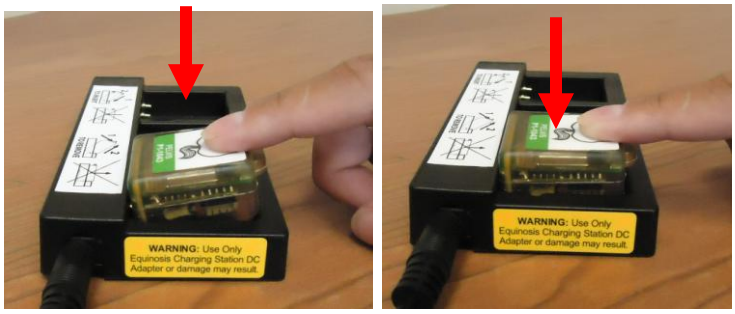
- Plug the battery charger into a standard AC, 110-volt, wall socket using the Equinosis 5V-DC power adapter cord.

ONLY USE THE DC ADAPTER SUPPLIED WITH THE LAMENESS LOCATOR® BATTERY CHARGER. THIS IS A 5 VOLT DC ADAPTER. USING A HIGHER VOLTAGE DC ADAPTER WILL DESTROY THE SENSORS.

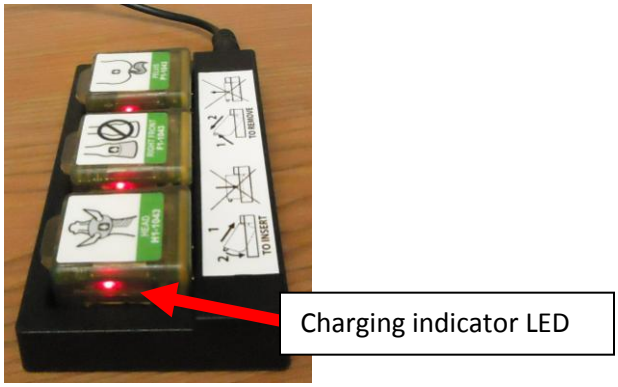
- Insert the sensor into the charging station bay as indicated below, **at an angle**, such that the conductive plates on the end of the sensor line up with the charging station pins.



- Press the end of the sensor with the lip down to snap the sensor into the bay.
  ****Note- attempting to force the sensors into the charging station bay otherwise, may damage the charging station pins.**



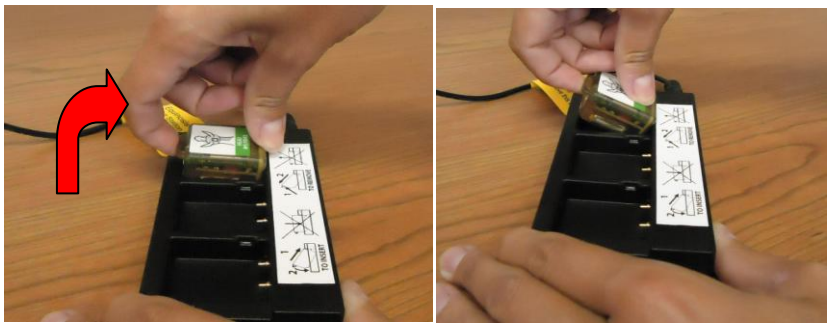
- When the sensor is correctly inserted into the charging bay, a RED LED on the left side of the sensor will turn on indicating charging has begun.



- When sensors are fully charged, this LED will turn off.

Removing the Sensors From the Battery Charger

- Hold the battery charger in the palm of one hand and use the thumb of the other hand to apply pressure inward and upward on the lip of the sensor. Once this end of the sensor is free, remove the sensor at an angle.



Prolonging long term life of the Lameness Locator® sensors

It is best **not to continuously charge sensors unattended overnight**. Unattended charging of the sensors overnight will repeatedly "top off" the sensor batteries and is not recommended for routine charging. Repeating this night after night will degrade long term battery life due to progressive battery terminal corrosion.

The sensors will require 1 to 2 hours to fully charge from the fully depleted-low voltage state. Charging will be considerably faster when only partially discharged. Sensors are fully functional without full charge.

Do not leave the Lameness Locator® sensors inside the car or truck cab during a hot day. The lithium polymer batteries will degrade more quickly at high temperatures. Also, and most importantly, if the temperature rises above 138 degrees F, the battery may combust or become irreversibly damaged.

Attaching the Sensors to the Horse (Instrumenting the Horse)

Attaching the Head Sensor

Turn on all sensors prior to attaching them to the horse. There are two appropriate methods of attaching the head sensor, using either the custom designed Equinosis® head bumper, or attaching directly to the crownpiece of a halter. **In either case, the sensor should be attached with the label side facing up and the green LED facing the horse's LEFT side. The drawing of the horse head on the label of the sensor should be oriented to match the direction of the horse (i.e. nose to nose). Also, the sensor should be on the most dorsal aspect of the head, as close to the poll as allowable by the felt head bumper or halter.**

When attaching the head sensor, it is important to check that the head halter fits the horse snugly. If the halter is too big for the horse's head, the halter may rotate on the horse's head as the horse is restrained by the handler with the lead shank while the horse is moving (especially in misbehaving or excited horses, or during the lunge). One easy method of tightening up a halter that is too large on the horse's head is to simply bunch up the nose band and connect straps attached to the tie ring with some tape.

Attaching the Head Sensor to the Lameness Locator® Neoprene Head Bumper

Attaching the head sensor to the Lameness Locator® felt head bumper is, in most instances, the best method. The location of the sensor attachment site on the bumper is in a previously-determined, optimum position for measuring the head acceleration most applicable for detection of lameness in the horse trotting over ground.

Also, attaching the head sensor to the Lameness Locator® felt head bumper reduces wiggle and noise from the head sensor during data collection. While attached to the head bumper, the sensor will move more reliably in better synchrony with the entire head. The head sensor is simply "snapped" onto the

head bumper by pressing the sensor into the 3M Dual Lock tape pad on the head bumper immediately in front of the halter strap loop. For best results, after attachment of the head sensor, the user should check that the head sensor is situated as close to the midline of the poll as possible before collecting data. This is best evaluated while viewing from the front of the horse.

Attaching the Head Sensor Directly to the Head Halter

In horses that are too head shy to tolerate placement of the felt head bumper over the ears, or that will not wear the bumper without excessive head shaking, the sensor can be attached to the most dorsal aspect of the crownpiece of a halter or bridle (see picture above). When the sensor is attached in this position, the vertical movement of the head measured by the sensor is attenuated slightly, especially if the horse carries its head high during the examination. However, since the lameness analysis algorithms rely on the *shape* of the vertical head movement signal, and not on the absolute amplitude of the signal, this is in most horses of only minor importance.

To attach the sensor to the halter, a strip of 3M Dual Lock tape can first be attached to the most dorsal position on the crown piece of the halter. With most clean Nylon or cloth halters, the sticky side of the 3M Dual Lock tape will usually be strong enough by itself to hold the sensor for at least a few trials. Alternatively, the 3M Dual Lock tape strip can be taped or glued into this position on the head halter. The sticky side of the 3M Dual Lock tape does not affix well to leather halters, especially if they are dusty or soiled. One solution that has worked well is to have, on hand, halters of different sizes with the 3M Dual Lock tape already glued in place. One should take care to use a sufficient length of 3M Dual Lock tape since adjusting the buckle of the crown piece after attaching the sensor will likely move the sensor off of the most dorsal aspect and require repositioning.

Attaching the head sensor to a round or rope halter or bridle is best accomplished using the felt head bumper.

Attaching the Right Forelimb Sensor

The right forelimb sensor should be applied to the dorsal aspect of the right forelimb pastern. It can also be applied to the dorsal aspect of the right forelimb hoof wall, but putting the sensor on the hoof wall should only be attempted when the horse is examined on a hard, flat and smooth surface. Putting the sensor on the dorsal hoof wall and trotting the horse in dirt or sand may damage the sensor.
Putting the right forelimb sensor on any other but the right forelimb will result in incorrect results.

The right forelimb sensor should be attached to the right forelimb pastern with the label facing out (not against the limb) and the green LED facing LATERALLY. The drawing of the distal limb on the sensor label should match the orientation of the horse. **Putting the sensor on the limb backwards, with the label facing the limb, or upside down, will result in incorrect results. The results will be exactly opposite of correct (i.e. the wrong limbs will be selected for lameness) for both forelimb and hind limb evaluations.**

The right forelimb sensor should be placed on the dorsal aspect of the pastern **with its long axis parallel to the long axis of the limb**. If the sensor is not parallel with the long axis of the limb, due to either improper positioning, or rotation greater than about 30 degrees off midline, mistakes in the analysis may occur.

Using the Lameness Locator® Pastern Wrap Pouch

The pastern wrap pouch should be wrapped around the right forelimb pastern. Position the first part of the wrap on the limb such that, when fully encircling the limb, the pastern pouch is situated on the most dorsal aspect of the pastern. To achieve this position in most horses, the wrap should be started on the dorsal or dorsolateral aspect of the pastern. For smaller horses, start more dorsally. For larger horses, start more laterally. Wrap snugly around the pastern in a **clockwise** direction. After completing the wrapping, secure with attached hook and loop tabs. Attach the pastern sensor by pressing the 3M Dual Lock Tape on the bottom of the sensor to the Velcro patch on the pastern wrap. Pull the sensor pouch up around the sensor and secure with hook and loop tabs. **The green LED should be facing laterally.**

If data is to be collected on excitable horses, especially while lunging, an additional single strip of elastic cloth tape may be used to secure the proximal edge of the pastern wrap. This will help prevent the pastern pouch from rotating on the limb and causing the sensor to “move” from the dorsal aspect of the pastern. If the pastern sensor moves significantly (more than 30 degrees) from the dorsal position, lameness analysis will likely be incorrect.

Attaching the Pelvic Sensor

The pelvic sensor is attached between the tubera sacrale on the dorsal midline of the pelvis. In most horses, this is the highest point of the pelvis. The sensor is attached to a strip of 3M Dual Lock tape spanning the tuber sacrale. Care should be taken to ensure that the sensor is on midline. This is best accomplished by viewing sensor location from behind with the horse standing squarely on both hind limbs. **The pelvis sensor should be attached with the labeled side facing up and the LED facing to the horse's LEFT.** The drawing of the pelvis on the sensor label should be oriented in the same direction of the horse (i.e., tail to tail).



Finding the Center of the Dorsal Pelvis (Between the Tuber Sacrale)

In most horses, finding the tuber sacrale is not difficult. In fat horses or in horses with voluminous gluteal muscle mass, it may be challenging. One method that works well in any horse is to first palpate the dorsal spinous processes of the lumbar vertebra, moving straight back until the most dorsal aspect of the pelvis is reached (see picture below). The center between the tuber sacrale should be within this area.


Attaching the 3M Dual Lock Tape Across the Tuber Sacrale

The pelvis will rotate to one side when the horse is not standing with equal weight on both hind limbs. It is important to try to find the center between the tuber sacrale when the horse is bearing weight equally on both hind limbs. Using a long piece of 3M Dual Lock tape (approximately 2 inches) to span across the tuber sacrale area will give the user latitude for repositioning the sensor later, if needed. In many cases, the 3M Dual Lock tape will stick to the body well enough without clipping of hair or additional gluing or taping. In horses with very long hair, especially if it is dirty, shortening the hair in the area with clippers may be necessary.

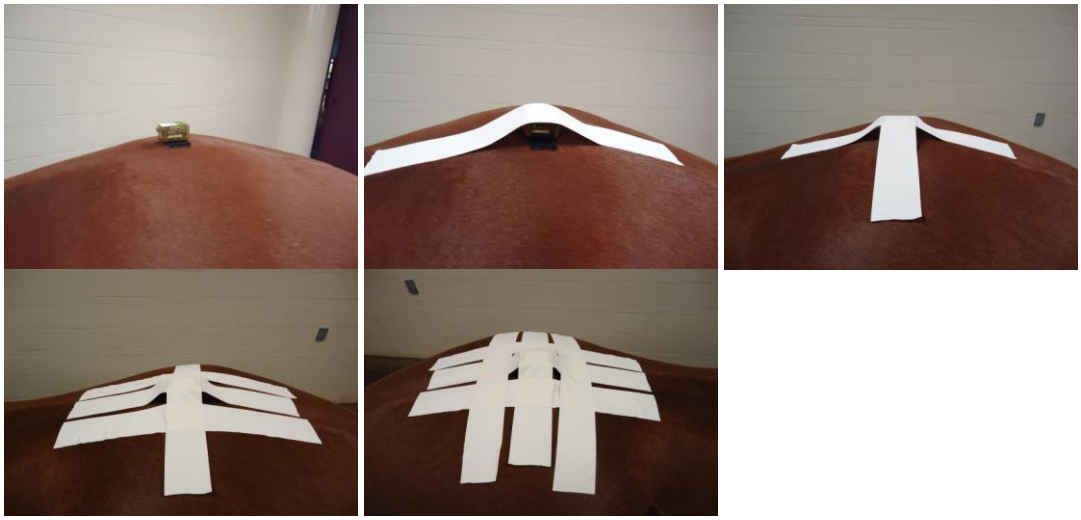
Attaching the Pelvic Sensor to the Strip of 3M Dual Lock Tape on the Pelvis

In horses with short and clean hair, it will usually suffice to simply press the 3M Dual Lock tape on the underside of the pelvic sensor strip of 3M Dual Lock tape on the horse. The exact center between the

tuber sacrale can be found by pressing your finger down on the 3M Dual Lock tape strip (see picture below). The deepest valley induced by this pressure is the approximate center between the tuber sacrale. After attaching the sensor to the 3M Dual Lock tape strip on the horse, the midline position should be checked by standing behind the horse and viewing while it is standing squarely on both hind limbs.

Using Reinforcement Tape to Stabilize the Pelvic Sensor

In horses with long hair, horses that are dusty or dirty, horses that may sweat, horses that are wet, or horses with hair that is slick (e.g., after being groomed with commercially-available products), it is best to stabilize the pelvic sensor by additionally securing it with reinforcement tape. The purpose of the tape is to stabilize the sensor and prevent it from wiggling independently of the vertical motion of the pelvis. Wiggling will create noise in the signal which will make the data analysis more difficult. A good rule of thumb to use to decide if additional reinforcement is required is to assess sensor attachment by grabbing and lifting it slightly pulling gently up. If the sensor moves up by more than a few millimeters, this indicates that the 3M Dual Lock tape strip applied to the horse is sticking only to the hair and not to the skin of the horse. Additional taping will make data analysis more accurate and easier to accomplish, particularly if evaluating subtle hind limb lameness. The taping should apply downward pressure on the top of the sensor and does not need to conform to the sides of the sensor. A recommended method of taping is presented below. In some cases, two strips criss-crossed may be sufficient. For added security, up to six strips may be used.



Utilizing the pelvic clip attachment accessory:

This new attachment accessory was devised to provide secure and firm pelvic sensor attachment without additional taping, which will be most advantageous in horses with long hair, slick coats from grooming sprays, and in horses that will sweat. However, this plate may be used in any horse, and users may find that setup time will be further reduced by using this plate.

- Two types of plates are included with the system. One has dual lock tape on both sides of the plate, and one has dual lock tape on only the top portion of the plate. The conformation of the pelvis will dictate which plate will work best for the individual horse.
- For horses with well-defined gluteal musculature and a marked depression between the tuber sacrale (such as well-fed Quarter Horses), you may elect the plate with dual lock tape on both sides of the plate, which elevates the plate slightly. This allows some tension to be put on the plate by the clips.
- In horses with prominent tuber sacrale, and/or decreased gluteal musculature, use the plate with dual lock tape on only one side, otherwise too much tension will be on the plate and it may not properly grab the hair. Note - In some horses with extremely prominent sacral tuberosities the pelvic sensor plate may not be the best alternative for attachment and taping may still be necessary.

1. Attach the sensor to the plate with the sensor LEDs facing one of the clips.
2. Place the plate over the sacral tuberosities taking into consideration the correct position and orientation of the pelvic sensor. The sensor should be on the dorsal midline with the plastic lip projecting forward and the LEDs facing towards the left side of the horse.
3. Open one clip, press down slightly and grab a tuft of hair (pinching as many stands of hair as possible).
4. Repeat for the opposite clip.
5. Gently pull the sensor up to verify if the plate is well attached to the horse.

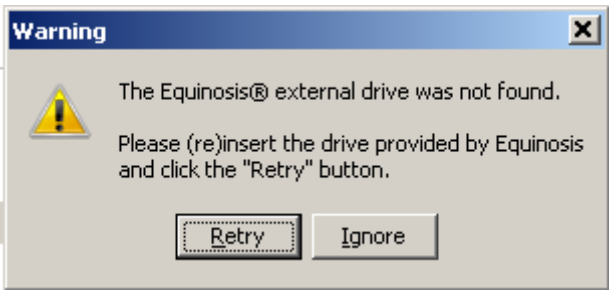
LAMENESS LOCATOR® SOFTWARE

Opening Lameness Locator®

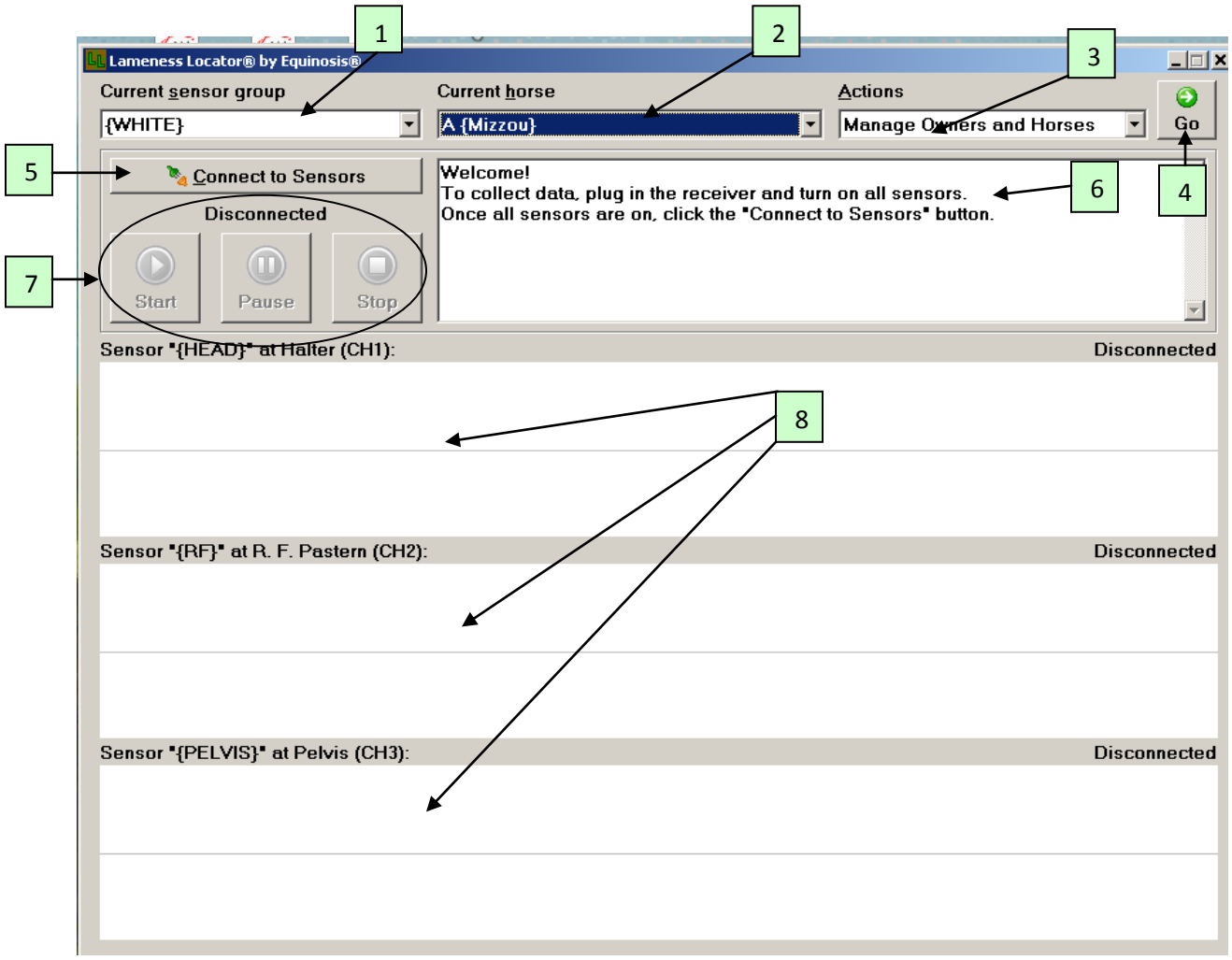
Double-click on the Lameness Locator® icon on the desktop.

Select **YES,** when prompted, to allow Lameness Locator® to open. Wait for the splash screen to load.

If you are not utilizing the Equinosis back up drive, this message will appear. Select ignore to proceed with start up.



Overview of Lameness Locator® Start Screen



There are three drop down menus along the top of the screen: 1) Current sensor group, 2) Current horse, and 3) Actions. There is 4) one green GO button (Go), 5) one toggle button to Connect to and Disconnect from the sensors (Connect to Sensors), 6) a text screen for messages, 7) three "video player-like" buttons for starting, pausing and stopping data collection, and 8) a large area for live display of data collection from all three sensors.

- Current sensor group: Selects the unique three sensor set to be used to collect data. The user must select the correct set of sensors from the drop down menu (sets are named via their color coded labels) before collecting data.

- Current horse: After connecting to the sensors, **any data collected will be placed in the folder and associated with the horse and owner displayed in the Current**

horse drop down text box. To be included in the Current horse drop down list, the owner and horse must have been previously entered by the user into the database. (See Manage Horses and Owners) **This is important! You must ensure that the horse to be measured is displayed in the Current horse drop down text box before collecting data.** The list is arranged in alphabetical order by horse. The name of owner is enclosed in curly brackets {} following the name of horse.

- Actions: There are five selections in the Actions drop down list. 1) Manage Horses and Owners, 2) Add New Horse, 3) Analyze Trial Data, 4) Archive Data for Export, and 5) About Lameness Locator®.

  - Manage Horses and Owners: Selecting "Manage Horses and Owners" brings the user to the Manage Owners window. This will be the most commonly selected option from the Actions drop down list. The user will select this option when first adding a new owner and horse to the database.
  - Add New Horse: Selecting "Add New Horse" brings the user to the Manage Horses window. If another horse owned by this owner has previously been added to the database, then the user can directly add another horse to the database.
  - Analyze Trial Data: Selecting "Analyze Trial Data" brings the user to the Manage Trials window for the horse selected in the Current horse drop down list.
  - Archive Data for Export: This option brings the user to an Export Data window. Within the Export Data window, the user can name, compress and backup all sensor and report data in a folder of choice. Back up should be performed regularly (i.e. weekly), and the zipped folder should be moved to an external hard drive for storage.
  - About Lameness Locator®: Selecting "About Lameness Locator" displays Lameness Locator® software version information.

- Green GO button (

): Selecting this button activates the selection in the Actions drop down box.

- Connect and Disconnect toggle button: The first selection connects to sensors. Subsequent selection disconnects from sensors.

NOTE: Once sensors are connected, Current sensor group, Current horse, and Actions drop down lists become inactive.

- Message area: Messages appear to inform users of connection status or errors in Lameness Locator® software.

- Start/Pause/Stop Buttons: start, pause and stop data collection.

NOTE: Start, pause and stop data collection buttons are inactive until sensors are connected to the receiver of the Motion Computing tablet PC.

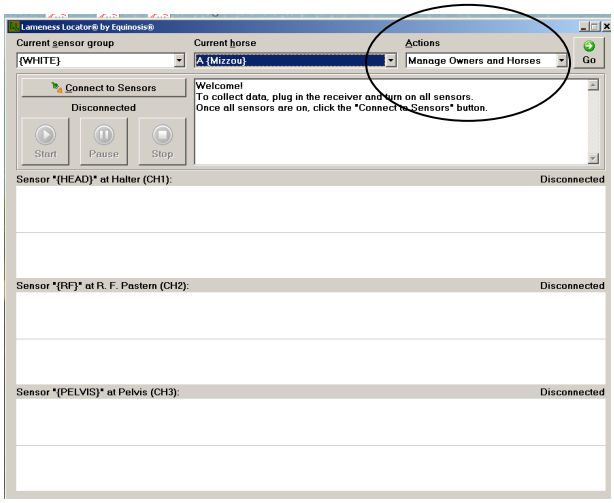
- Live display area: a “strip chart-like” area indicating streaming live data collection for all three channels. The top chart displays live vertical head acceleration. The middle chart displays live right forelimb pastern angular velocity. The bottom chart displays live vertical pelvic acceleration. When the signal reaches the far right edge of the screen, it will continue at the left edge of the screen.

ADDING NEW CASES TO THE DATABASE

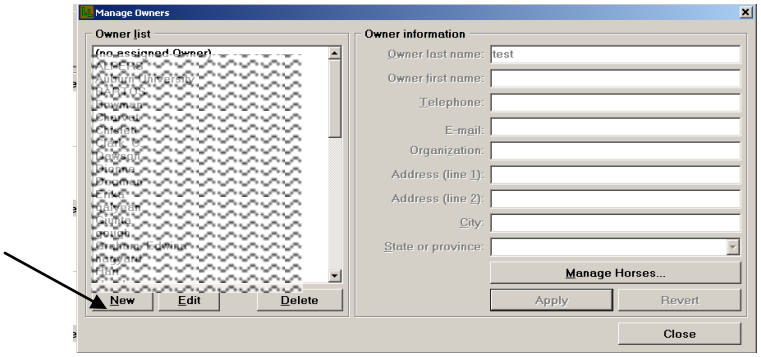
A case must be added to the database before any data can be collected. Adding a case to the database populates (i.e. adds a new entry to) the Current horse drop down list. Most often, the user will need to add both a new owner and a new horse to the database. In some cases, when owners have multiple horses, any subsequent cases added after the first horse can be directly added to the database without re-entering owner information. **NOTE: Once a horse is added to the database, the information does not have to be re-entered for future evaluations. The user simply selects the horse from the Current horse drop down menu.**

ADDING NEW OWNER AND HORSE INFORMATION:

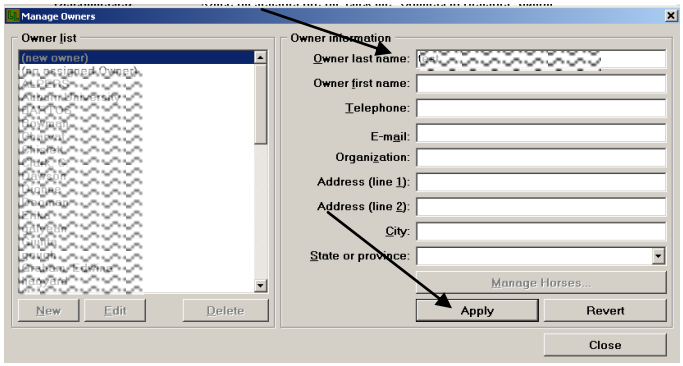
- If necessary disconnect from the sensors. Select **Manage Horses and Owners** from the **Actions** drop down list.



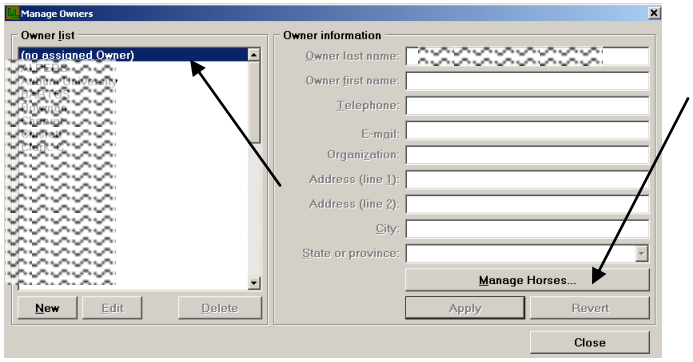
- Select green **GO** button.
- This opens the **Manage Owners** dialog box. Select **New**.



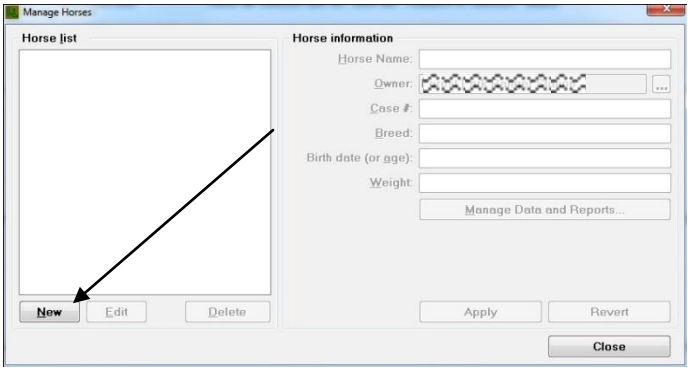
- Enter information about owner. Note: Owner last name is the only required field. Select **Apply** to save.



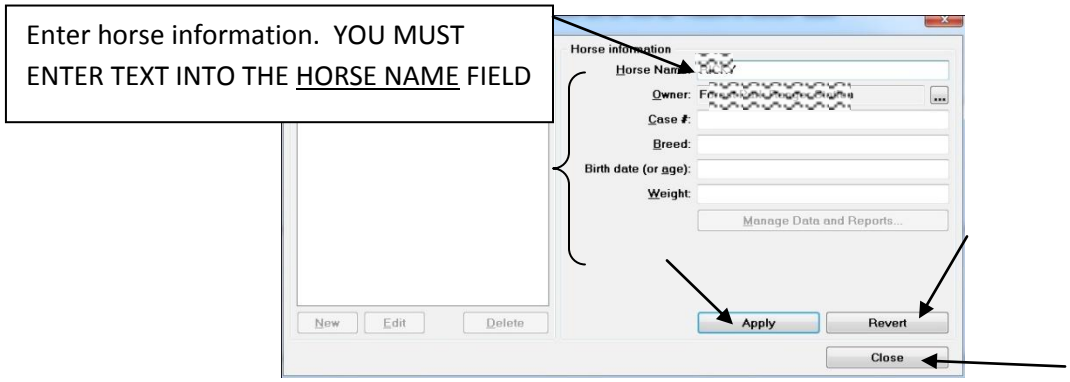
- Selecting **Apply** returns to the **Manage Owners** dialog box. The owner just entered will appear in the Owner List. Double click on the highlighted owner or select **Manage Horses…**.



- This brings the user to the **Manage Horses** dialog box. Select **New**.



- Enter identifying information about the horse. **You must enter text into the Horse Name field.** Entering information into all other text boxes is optional. Entering text into the Name field will activate the **Apply** and **Revert** buttons.

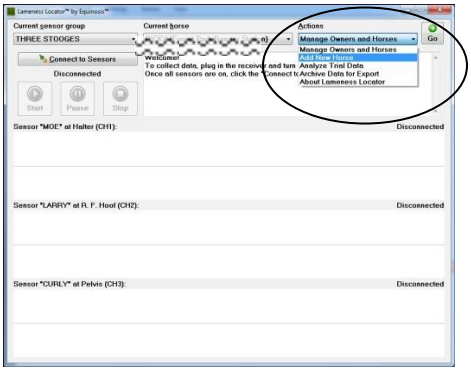


- Select **Apply** to save or select **Revert** to erase entered data and return to a blank Manage Horses window. After saving horse information, close the window by selecting **Close** twice to return to the Lameness Locator® start screen (to get ready to collect data). The horse just entered will now appear in the Current Horse field.

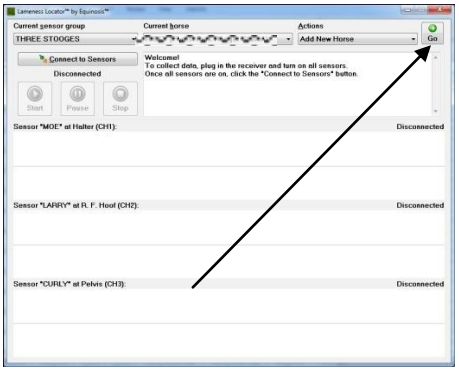
******THE MOST COMMON REASON FOR FAILING TO POPULATE THE CURRENT HORSE DROP DOWN LIST IS FAILING TO SELECT APPLY AFTER ENTERING THE NAME OF THE HORSE.******

ADDING A NEW HORSE WHEN OWNER ALREADY IN THE DATABASE:

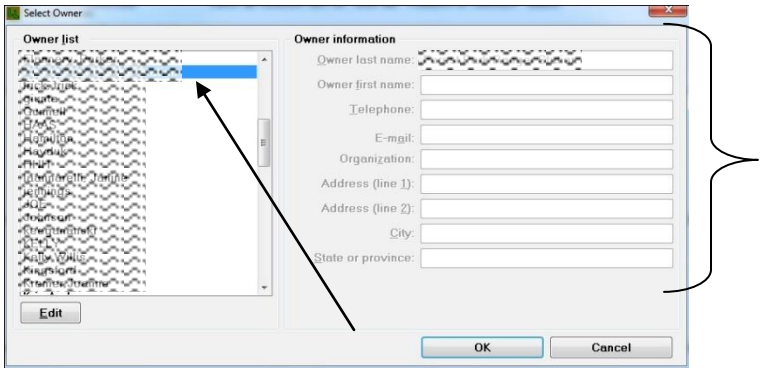
- Select **Add New Horse** from the **Actions** drop down list.



- Select green **GO** button.

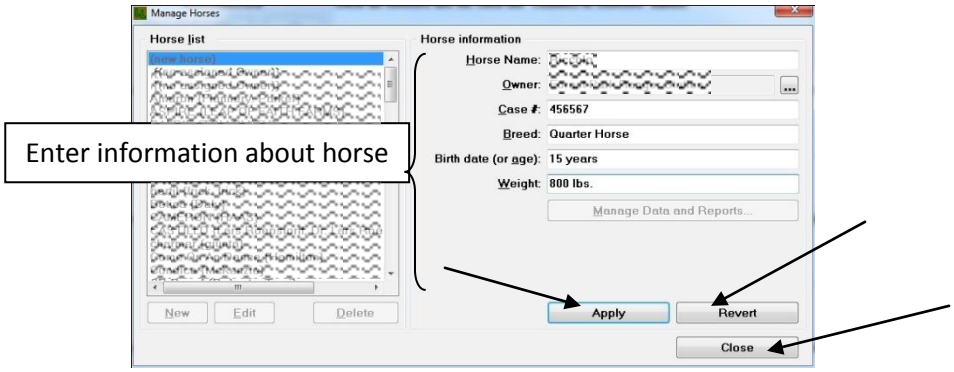


- This opens the **Manage Owners** dialogue box.
- Browse in the Owner list for a desired owner, and **select to highlight**.



Note that when the owner is selected, the owner information boxes become populated with previously entered information for the selected owner.

- Select the **Manage Horses** button.
- Select "New".
- Enter information describing the horse. **You must *at least* enter information in the Horse Name text box.** Every other field is optional. The Apply button will not become active until you enter text into the Horse Name field.



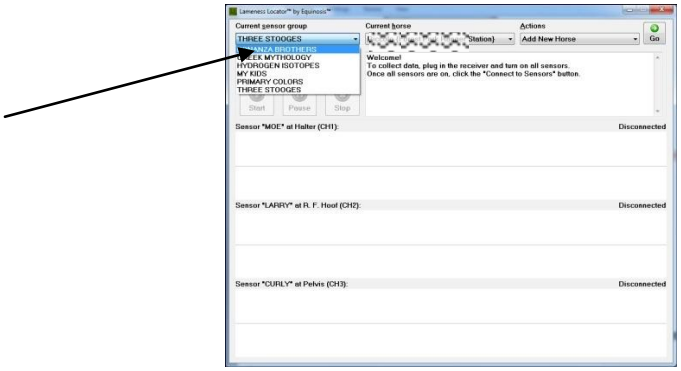
- Select **Apply** to save this information, or select **Revert** to erase entered data and return to a blank Manage Horses window. Close the window by selecting **Close twice** to return to the Lameness Locator® start screen (to get ready to collect data). This horse will now appear in the Current Horse dropdown field.

****THE MOST COMMON REASON FOR FAILING TO POPULATE THE CURRENT HORSE DROP DOWN LIST IS FAILING TO SELECT APPLY AFTER ENTERING THE NAME OF THE HORSE****

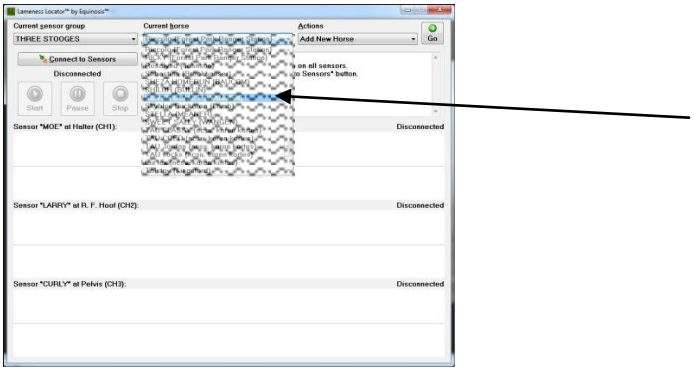
STEP BY STEP: DATA COLLECTION

- Insert the USB receiver into a USB port in the tablet PC. Turn on your sensors and instrument the horse as previously described.

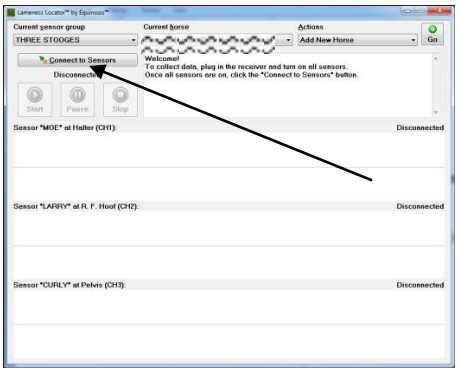
- Open Lameness Locator® program.
- Select the correct set of sensors, if more than one set is owned and available.



- Enter owner and horse information as previously described, or choose the appropriate horse from the current horse drop down menu if previously entered.



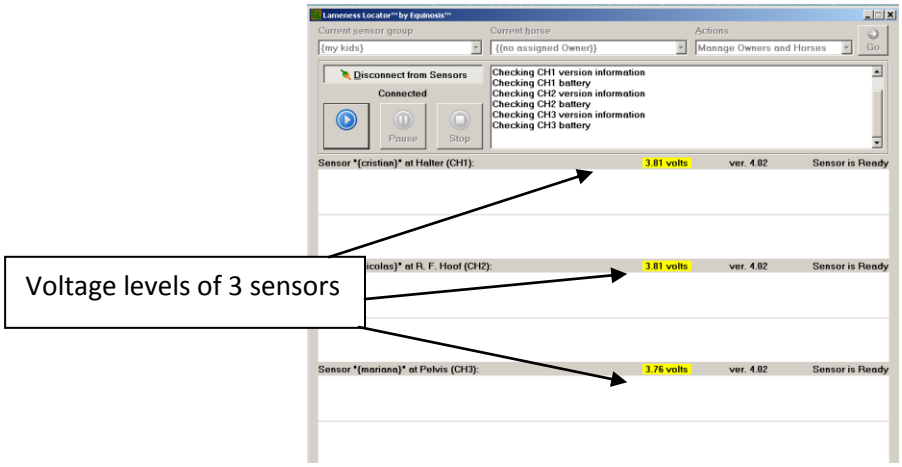
- Select **Connect to Sensors** on the Lameness Locator® start screen. 



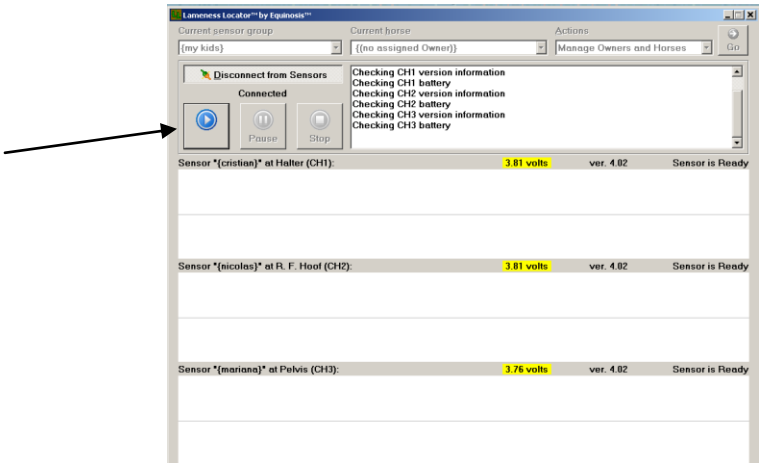
After this button is selected and the sensors are found and connected to the LL software, the small "unplugged" icon on the Connect to Sensors button will change to a small "plugged" icon. If the software cannot connect to the sensors, a message will be displayed in the text box at the top of the window indicating no connection. ****** Common reasons for not being able to connect to the sensors are 1) sensors are not turned on, 2) the USB receiver is not plugged into the USB port, and 3) a sensor is not charged up sufficiently.**

- Lameness Locator® software will then query the battery status of each sensor. Check battery charge of sensors: Once all of the batteries on each sensor are checked, the Lameness Locator® software will display the charge state (in volts) of each sensor in a colored box above each channel. Consult table below for significance of different voltage levels.

CHARGE LEVEL COLOR	DESCRIPTION	SUGGESTED ACTIONS
GREEN	MAXIMUM CHARGE	NONE
YELLOW	MID-LEVEL CHARGE	APPROXIMATELY 30 TO 60 MINUTES OF ACTIVE CHARGE REMAINING
RED	LOW CHARGE	CONTINUE COLLECTION OF CURRENT TRIAL, BUT RECHARGE BEFORE NEXT DATA COLLECTION



- Select the **Start** button. Selecting the start button will open the Enter Basic Trial Information dialog box.



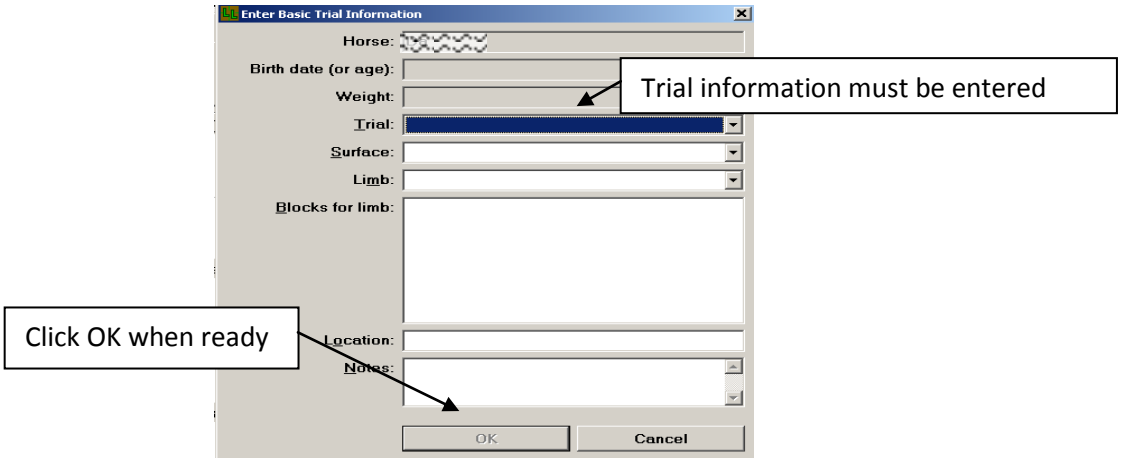
- Enter trial information by selecting a trial option from the drop down menu. Entering Surface, Limb, Block, Location and Notes are optional. **Trial options include straight line, lunge left, lunge right, before flexion, LF distal limb flexion, LF proximal limb flexion, RF distal limb flexion, RF proximal limb flexion, LH distal limb flexion, LH proximal limb flexion, RH distal limb flexion, RH proximal limb flexion, Straight uphill, and Straight downhill.** The user is also able to enter their own custom trial, surface and block options (refer to end of this section).

  Note: In order to select a block, the user must first choose the limb that is being blocked from the "Limb to block" drop down menu. After selecting limb blocked, a list of relevant blocks for the fore and/or hind limb selected will then appear in the "Blocks for limb" drop down list.

- Blocks performed previously will be stored and remain checked in the "Blocks for limb" drop down list if the next data collection occurs within two hours. All checked blocks will remain in the "Blocks for limb" drop down list in subsequent trials on the same horse and in reports

saved for that horse. Thus, it is unnecessary for the user to re-enter this information as an evaluation progresses and additional subsequent blocks are performed.

- When blocking, subsequent trials set up will always show the initial limb blocked, with its previously selected blocks, as the default. In order to add additional blocks to other limbs, if switching to another limb is indicated in an evaluation, the user must then select the desired limb. All blocks checked for each respective limb will be displayed in the report.

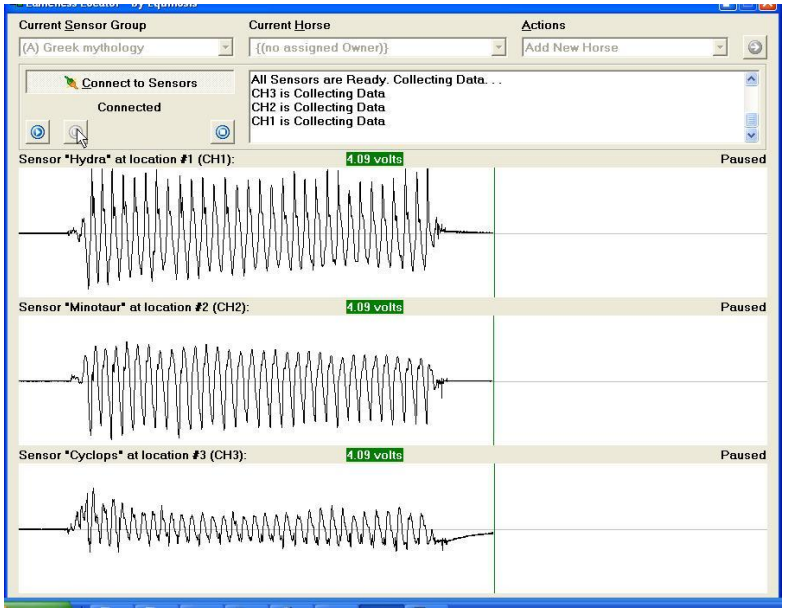


- To start collection of data, the user must enter information in the Trial box. All other information is optional. When information is entered in the Trial box, the OK button will be activated. **When the OK button is selected, data collection will be initiated. If you are not ready to begin data collection after selecting the OK button, select the Pause button until you are ready to initiate the trial and data collection**. For example, the horse may be instrumented in one location (an exam room) but then evaluated in another location. The pause button can be selected while the horse is being moved to this new location. Data collection is reinitiated by re-selecting the start button. ***Note that once connection to sensors is made and a trial is set up, it is best not to get too far from the horse, or introduce a barrier between the user and the horse (such as the horse moving to the outdoors while the user and tablet remain indoors), which may inadvertently disrupt the Bluetooth connection. In this situation, the user might then select the START button to initiate data collection, and the sensors will not collect data.

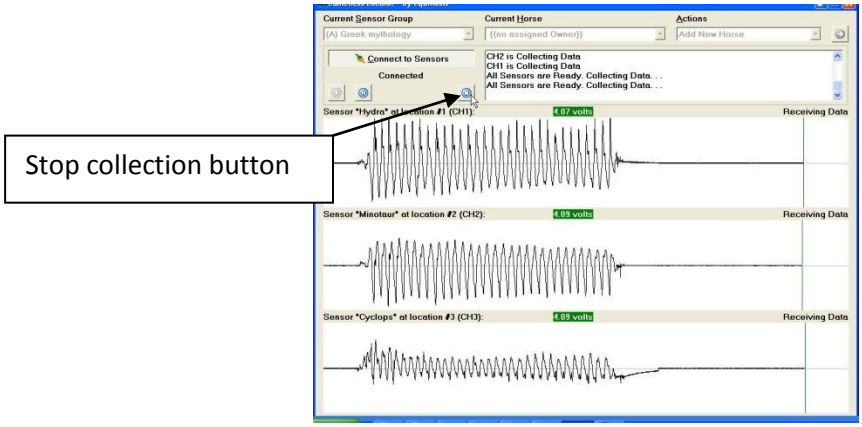
  Data collection is displayed in real time from all three sensors in a strip chart-like interface with sensor #1 (the head sensor) on top, sensor #2 (the right forelimb sensor) in the middle, and sensor #3 (the pelvic sensor) on the bottom of the window. Sensor #1 displays raw vertical head acceleration. Sensor #2 displays raw right forelimb pastern angular velocity. Sensor #3 displays raw vertical pelvic acceleration. When within range, the display of the sensors is synchronized, i.e. each channel tracks at the same rate. When approaching the limits of transmission range, the display of the three sensors may briefly lose synchronization; one channel may track at a slower rate than the other two. Loss of channel synchronization indicates that the horse is at the limit of the range of data collection. If the channels appear to be tracking at different rates

the subject should begin moving back towards the receiver. Resynchronization of channels within a few seconds will occur. Storage buffers on sensors will ensure channel synchronicity for correct results. Continuation of data collection at further distances after loss of channel synchronicity will abort data collection. No data will be saved and the trial will have to be repeated.

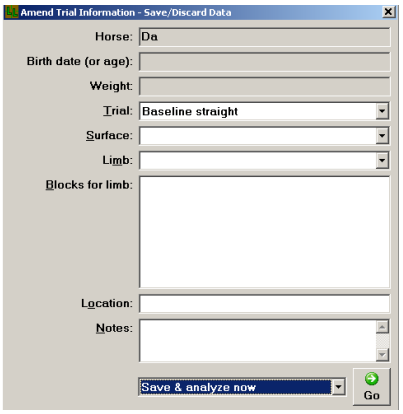
****Note: The user does not need to select the pause button when the horse stops and turns around at the end of a jog strip. LL will automatically discard any strides that fall outside +/- 10% of the median stride rate. The user can further adjust the selection of strides to be included during the analysis process****



- **Collect at least 25 total strides, with at least 6 contiguous strides before the horse stops and turns around.** After collecting the desired amount of data, the user can stop collection by selecting the **Stop** button.



- After selecting the stop button, the **Amend Trial Information - Save/Discard Data** window is displayed.



The user can amend information to the database for this collected trial, such as changing a field or adding notes. At the bottom of the window, the user has 5 options from a drop down menu for saving or discarding the collected data and for immediately analyzing. The user makes a selection followed by selecting the green arrow button.

- **Save & analyze now:** This is the default selection. Selecting this option saves the data, disconnects from the sensors and initiates data analysis of the trial just collected. This is the most common selection.
- **Save & collect again:** Saves the data, disconnects and then reconnects to the sensors without launching into data analysis. The user will have the option of analyzing the data just collected at a later time.
- **Save & disconnect:** Saves the data then disconnects from the sensors. The user is then free to select options from any of the three drop down menus on the main Lameness Locator® window (Current Sensor Group, Current Horse, Actions).
- **Discard & collect again:** Does not save data then disconnects and reconnects to sensors to prepare for another data collection.
- **Discard & disconnect:** Does not save data then disconnects from the sensors. The user is then free to select options from any of the three drop down menus on the main Lameness Locator® window (Current Sensor Group, Current Horse, Actions).

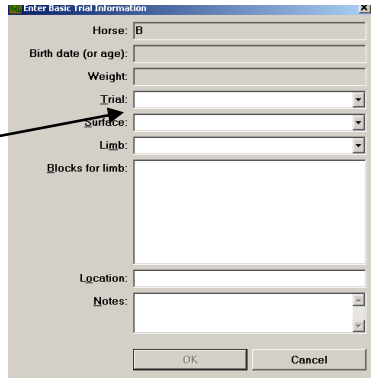
Adding Custom Trials, Surfaces, and Blocks:

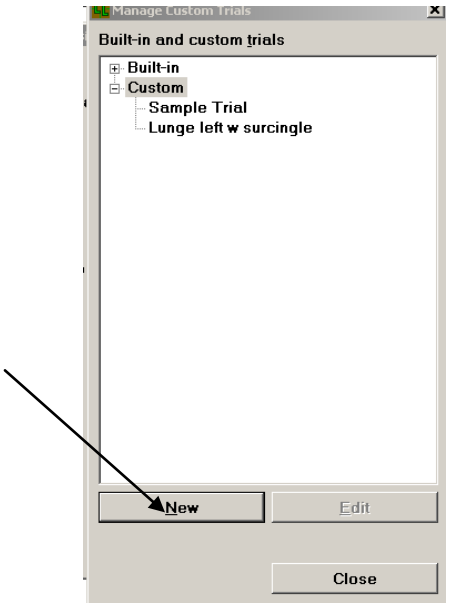
For additions to either the Trial or the Surface list:

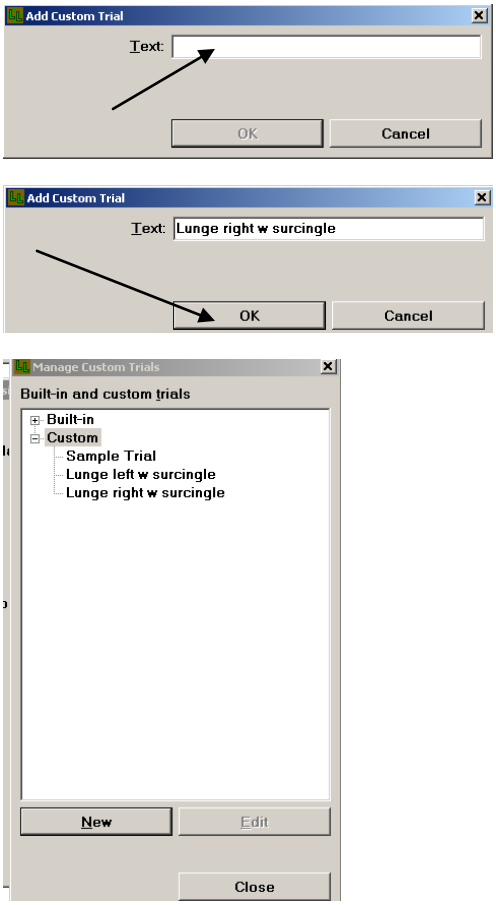
- To enter a custom Trial or Surface configuration, move the pen stylus over the desired heading you wish to add a custom option (Trial or Surface). When you move the stylus over one of these headings, you will notice that the curser changes to a hand. **Double click** to open the **Manage Custom Trials** or **Manage Custom Surfaces window.**

  - Select **NEW**. A text box will open. Enter the desired Trial or Surface respectively.
  - Select **OK**.
  - The new Trial or Surface option will now appear in the drop down menu for that heading. Note that custom additions will appear at the bottom of the list, they will not be listed alphabetically.

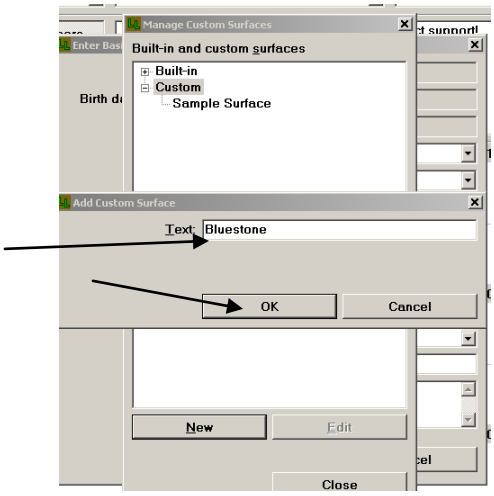
Custom Trial Entry Example







Custom Surface Entry Example

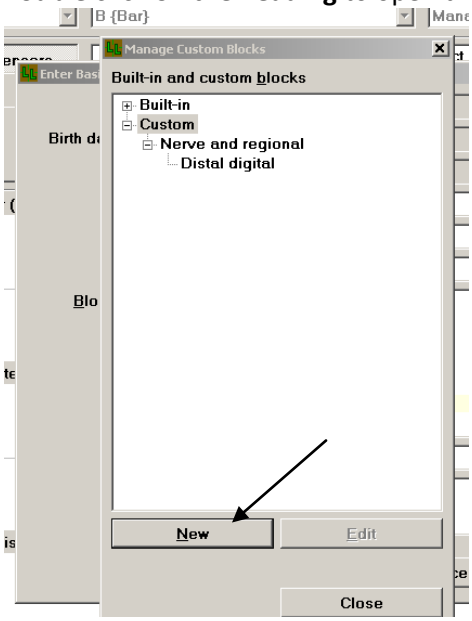


- You can also edit the Lameness Locator® preset lists by hiding them from appearing in the drop down menu (for instance, to reduce the length of options appearing in your drop down menu, you can hide presets that you do not use).
    - ➢ Upon opening a Manage Custom Trials, Surfaces, or Blocks window, select the plus (+) sign to expand the Built in trial list.
    - ➢ Select any trial/surface/block you wish to "hide"

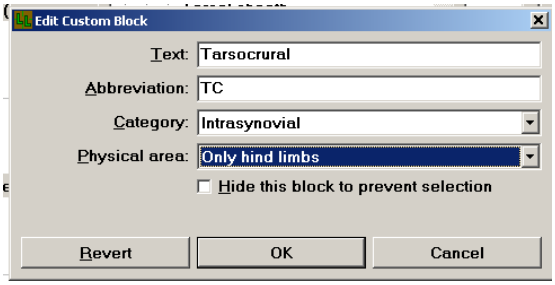
- Select EDIT
- Check the box "Hide this trial to prevent selection"
- Select OK

For the additions to the Blocks list:

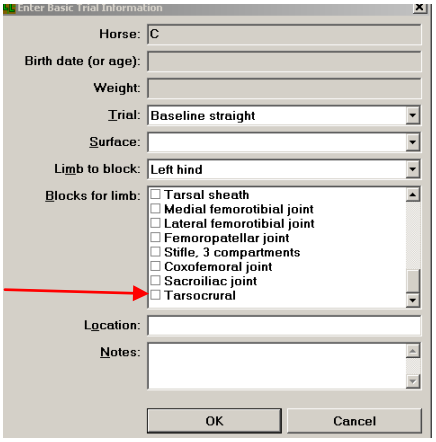
- To enter a custom Block configuration, move the pen stylus over the **Blocks for limb** heading. When you move the stylus over the heading, you will notice that the curser changes to a hand. **Double click on the heading** to open the **Manage Custom Blocks** window.



- Select **NEW**.
- In the Text window, enter the name of the block as you wish it to appear in the drop down menu.
- Enter an abbreviation for the block not more than 5 characters in length, that will be used in the reports and PDF save function.
- Choose a category of the block (intrasynovial, nerve and regional, or other).
- Choose which limbs the block might apply to (i.e. all limbs, only front limbs, only hind limbs, or other). Selecting the physical area that the block would apply will allow it to show up only in the list of forelimb blocks, only in the list of hind limb blocks, or both, etc….
- Select OK.



- Custom blocks will appear within the category of your choosing (intrasynovial, nerve and regional etc…) at the bottom of the respective list.



*** Note that you may, in the future, go into the Manage Custom Trial, Surface, and/or Block windows and edit your custom additions, by selecting the desired trial, surface, or block (single click to highlight in blue), and select EDIT. You may alter the information for that block, or check the box "Hide this trial/surface/block to prevent selection, so that it no longer appears in your drop down list.

*** Note that the expert system comments that are invoked when comparing pre and post blocks will ONLY be invoked when the user utilizes the STRAIGHT LINE preset trial option. Using custom trials will not invoke the expert system comments.

Rules of Thumb For Collecting Good Data:

- An ideal collected data set is a total of at least 25 strides from a well-behaved horse trotting in a straight line. Misbehaving horses, especially if there is excessive head shaking, rearing, trying to run off, bucking, kicking, etc., will not produce reliable or repeatable results. Although Lameness Locator® is equipped with algorithms that will, to some extent, disregard "bad strides", excessive bad behavior will increase variability of analysis. In bad-behaving horses it is prudent to collect more than 25 strides. Trotting the horse up and down twice in a 90 foot runway will suffice in most cases.

- It is best to collect at least six contiguous strides for every portion of a collected data set, i.e. before the horse turns around and trots back. Lameness Locator® software may not select starting and ending points of a particular segment to analyze if less than six contiguous strides are collected in that segment.

- Try to minimize gradual gait transitions from walk to trot by having the handler move off with the horse briskly. If the horse does not lead well, gentle prodding from behind by touch or sound may help.

- Try to minimize head jerking by encouraging the handler to avoid tugging on the lead shank to get the horse's attention. The handler should maintain control of the horse's head, but avoid influencing or inhibiting the horse's head movement.

- Use the Pause button when needed. If the horse is acting up while collecting data, such as cantering or bucking during lunging, the user can select the Pause button until the horse resumes regular trotting activity.

STEP BY STEP: GENERATING AN ANALYSIS REPORT

Overview

You can generate a Lameness Locator® Analysis report immediately after collecting data or you can batch collect many trials and generate the reports later. A report can be generated in less than 15 seconds. The default selection is **Save and Analyze Now**.

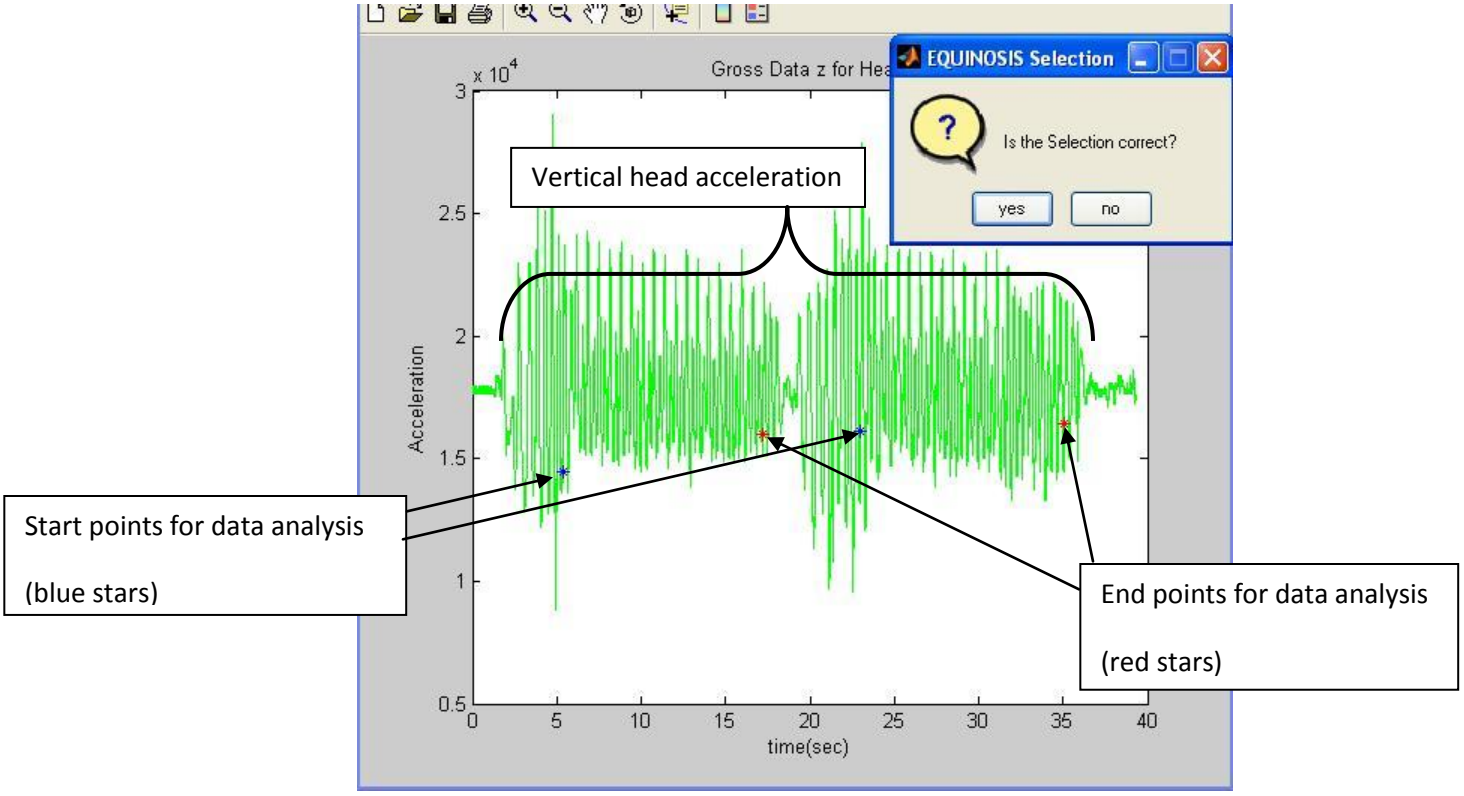
To analyze data immediately after stopping data collection, the user simply selects the **Green Activation Arrow Button**.

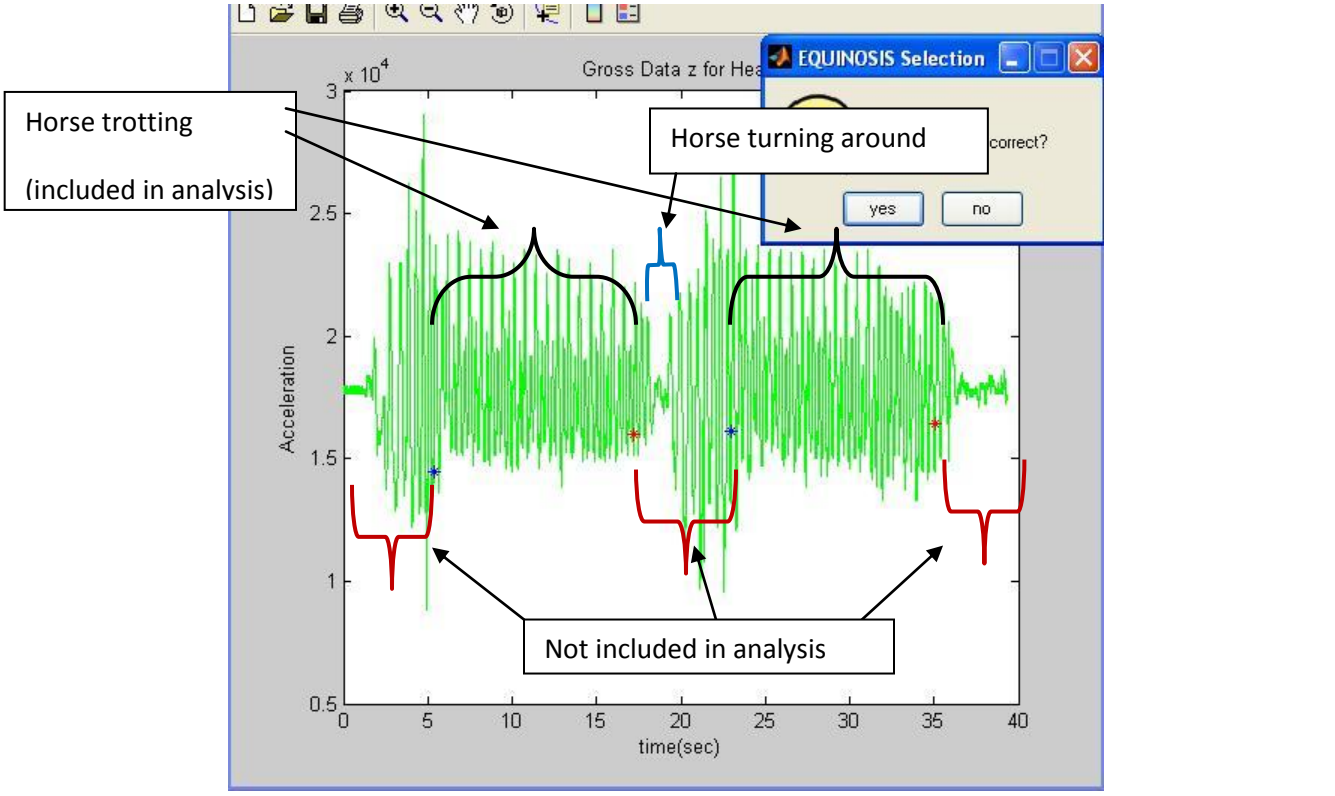
Display of head acceleration signal with segment selection will appear.

- A plot of raw vertical head acceleration (green signal) of the entire collected trial versus time is displayed.
- Blue and red asterisks on the raw head acceleration signal indicate the beginning (blue asterisks) and ending (red asterisks) time indices of the data in the trial that has been selected for analysis.

FIRST USER INTERACTION: The user is asked: "Is this selection correct?"

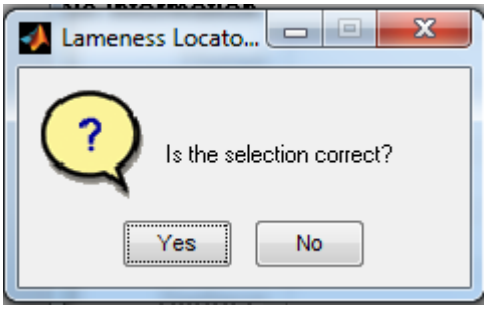
- Lameness Locator® uses a series of algorithms to determine when the horse is trotting. Only data from strides when the horse is trotting can be depended upon to give accurate determination of lameness with Lameness Locator®. Remembering how the data in the trial was collected, i.e. trotting back and forth twice in a straight line, trotting off once after a flexion test, or continuously lunging, will help the user determine whether the selected data is representative of the trial. For example, in the case below, the horse started from a standstill, trotted off in one direction, turned around, trotted back in the other direction, and then stopped.


Vertical head acceleration
Start points for data analysis
(blue stars)
End points for data analysis
(red stars)
EQUINOSIS Selection
Is the Selection correct?
yes
no
Acceleration
time(sec)


Horse trotting
(included in analysis)
Horse turning around
Not included in analysis
EQUINOSIS Selection
yes
no
Acceleration
time(sec)

- The **default analysis will include any stride within +/- 10% of the median stride rate**. Any strides not included between beginning blue and ending red asterisks will not be analyzed. For example, in the above case, the first parts of the trot in both directions will not be analyzed. The horse may not have taken off briskly enough to get into a regular trot within the first few strides. Also, notice in this horse, the vertical acceleration of the head as it takes off on a trot is greater than during the middle and end of the trial when it is slowing down. This is a common occurrence.

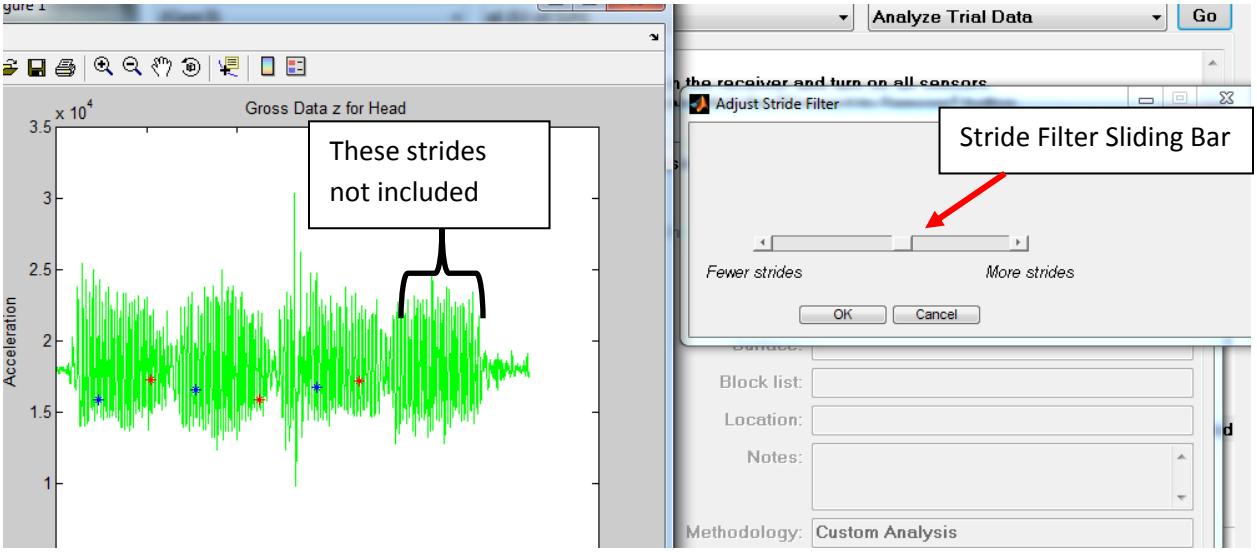
- There are two options to select from the "Is the selection correct?" dialog box:

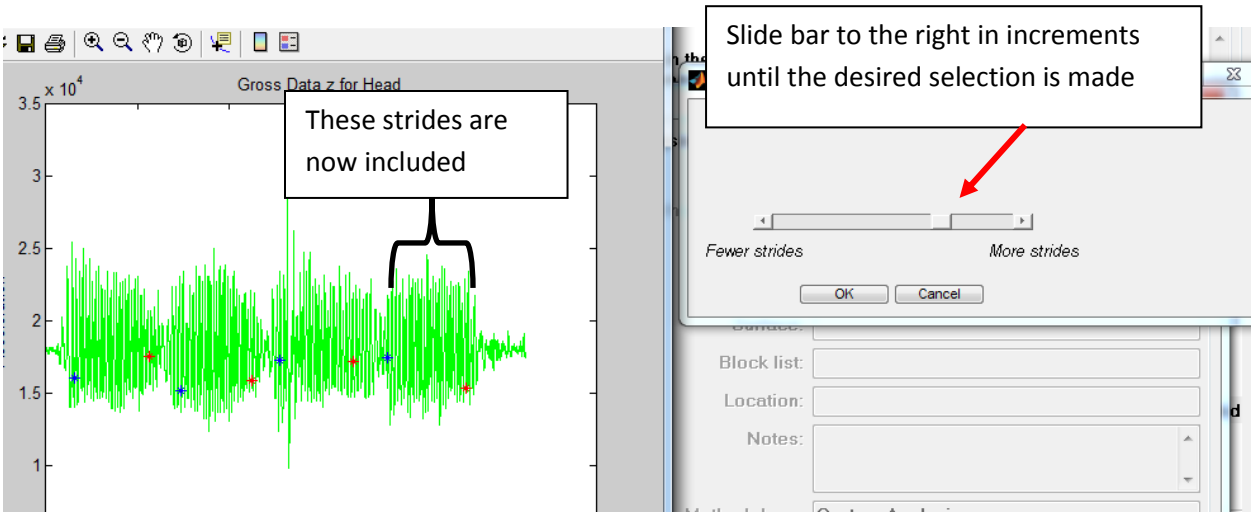


  - If the user is satisfied with the starting and end points, select "yes" in the Selection box. This will initiate further analysis. In most cases, the default selections of the starting and ending points are sufficient to give the best analysis.

  - If the user is not satisfied with the starting and end points, select "no".

In this example below, the last segment of strides was not included in the selection for analysis. This occasionally occurs if a minimum of 6 contiguous strides is not achieved in one direction (before the horse stops and turns around). By selecting "No", a stride filter sliding bar tool will appear. To increase the stride selection, slide the bar to the right in increments until the desired selection is achieved. To decrease the selection, slide the bar to the left in the same manner. The upper limit of the stride selection is 0.5, or strides that fall within +/- 50% of the median stride rate. If a selection is not made with the sliding bar pulled all the way to the right, then the variability of the stride rate was too great for this segment, and inclusion of those strides for analysis would not be desirable.





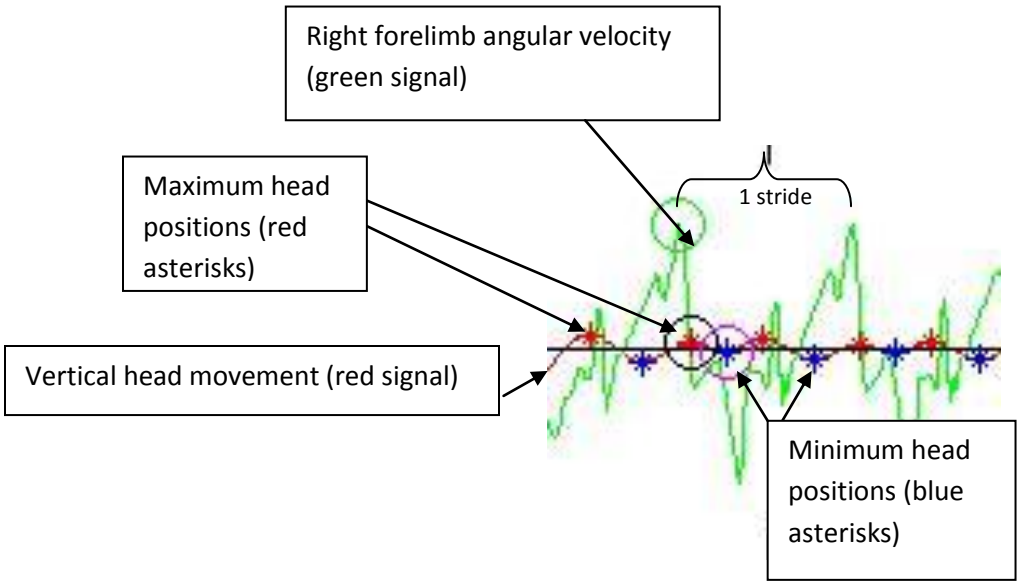
- When satisfied with the selection, select OK.

Plots of head and right forelimb signals

After selecting OK, forelimb lameness evaluation is initiated.

- During the processing, the user will notice a series of plots appearing and disappearing on the screen.
- Each plot is a graphical display of right forelimb pastern angular velocity (from the right forelimb sensor) and the computed trajectory of vertical head movement.

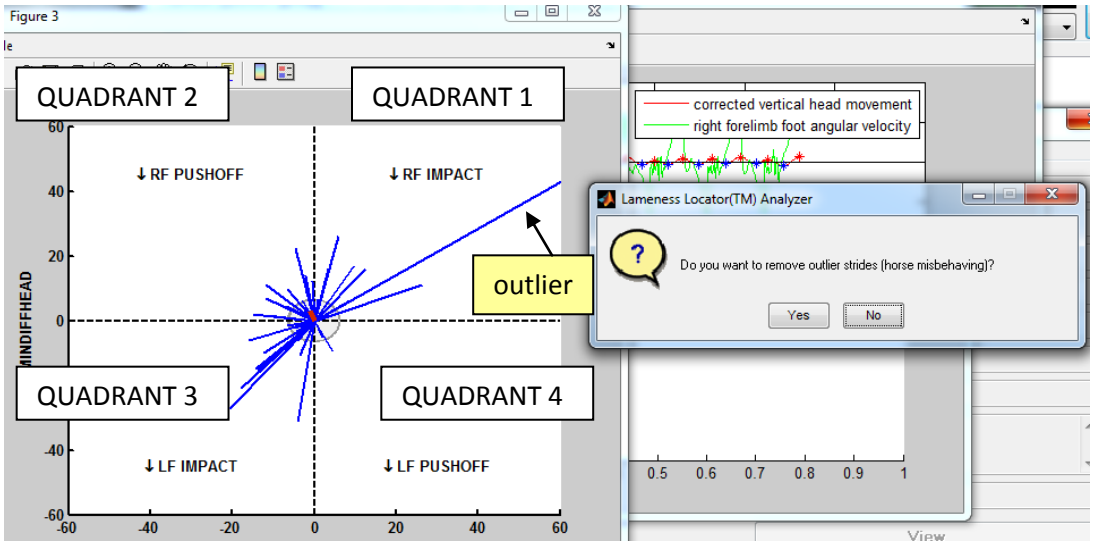
- The right forelimb pastern angular velocity signal is green. The head acceleration signal is red with red asterisks at head maximum positions and blue asterisks at head minimum positions.
- Each right forelimb angular velocity peak represents the approximate time of break over of the right forelimb foot.
- Below is an example tracing from just one stride of the signals being plotted.



SECOND USER INTERACTION. "Do you want to remove outlier strides (horse misbehaving)?"

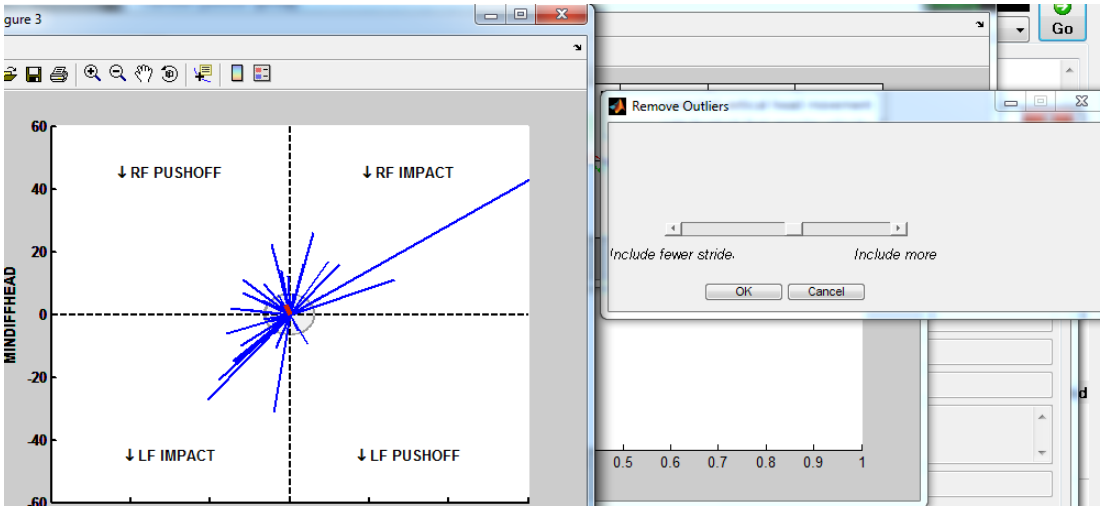
- The forelimb lameness ray diagram will then be plotted.
- A window appears asking the user "Do you want to remove outlier strides (horse misbehaving)?". Despite the presence of correction algorithms within the Lameness Locator® software that help reduce the influence of head tossing, it may be beneficial to utilize this option in horses that are misbehaving or tossing the head erratically. In current users' experiences, this occurs primarily when the horse is lunging. Removing outliers in these cases reduces the standard deviation of Max Diff Head and Min Diff Head in the final report. This reduction of variability will improve the confidence of forelimb lameness results. The presence of significant outliers can be assessed by inspection of the forelimb lameness ray plot. Rays much longer than most in a group, or that point in a direction away from the group, are outliers.

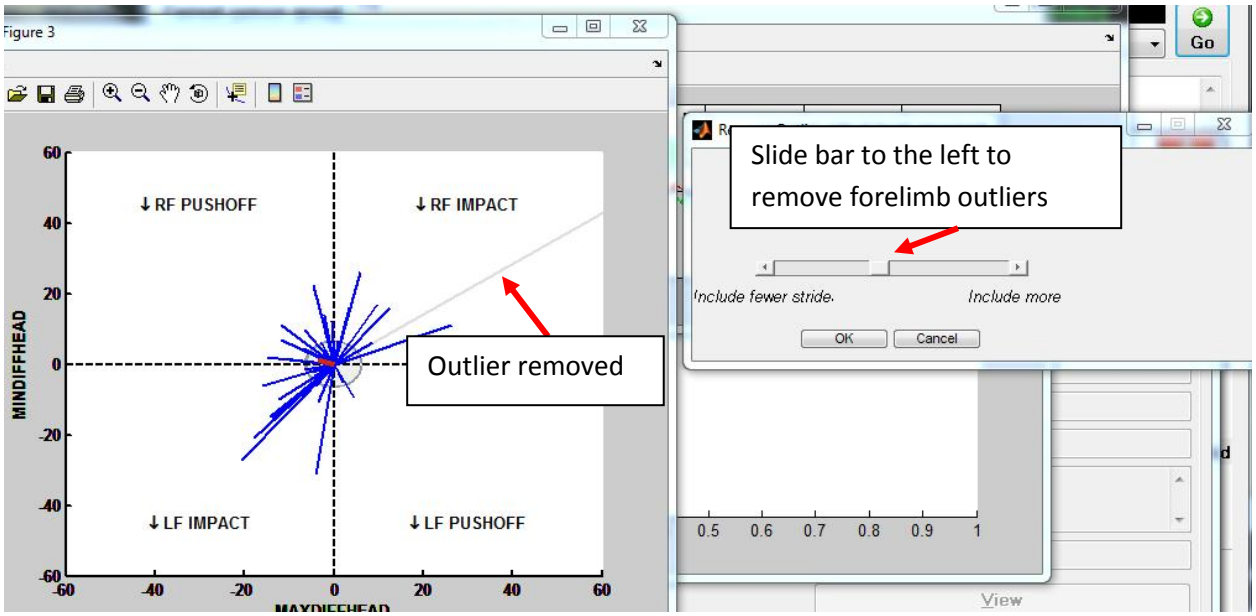
Forelimb Ray Diagram:



- If the user is satisfied with the forelimb results, select **NO**. This will initiate continuation of data analysis by initializing hind limb lameness evaluation.

- If the user is not satisfied with the forelimb results, select **YES**.
  - Selecting "Yes" will initiate display of a stride filter sliding bar tool that allows the user to delete outliers. Sliding the bar to the left will remove outliers, leaving them shaded gray so that you can determine what was removed.





- Once satisfied, select OK to complete hind limb analysis.

Plots of Pelvic and Right Forelimb Signals (Hind limb Lameness Evaluation)

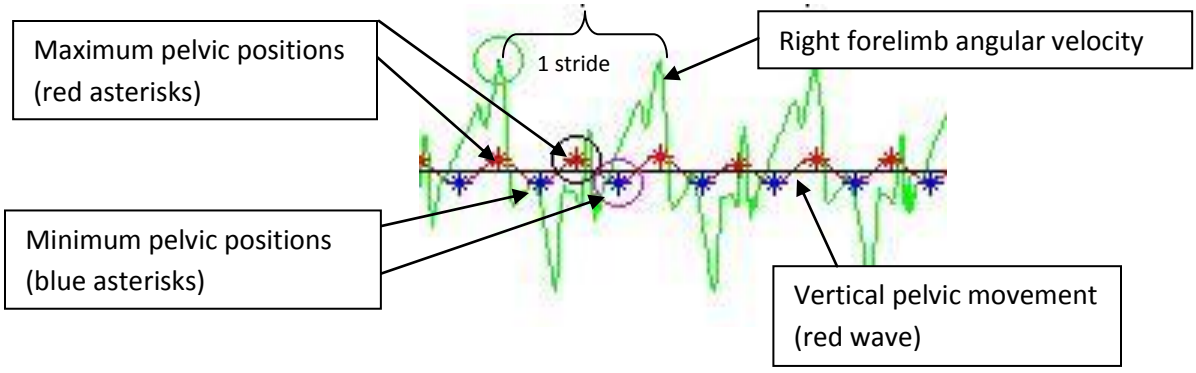
- Following the decision to remove outlier strides for the forelimb evaluation, another series of Lameness Locator® algorithms for evaluation of hind limb lameness are initiated.

- Each plot is a graphical display of right forelimb pastern angular velocity (from the right forelimb sensor) and the computed trajectory of vertical pelvic movement.

- The right forelimb pastern angular velocity signal is green. The pelvic acceleration signal is red with red asterisks at maximum positions and blue asterisks at minimum positions.

- Each right forelimb angular velocity peak represents the approximate time of break over of the right forelimb foot.

- Below is an example tracing from just one stride.



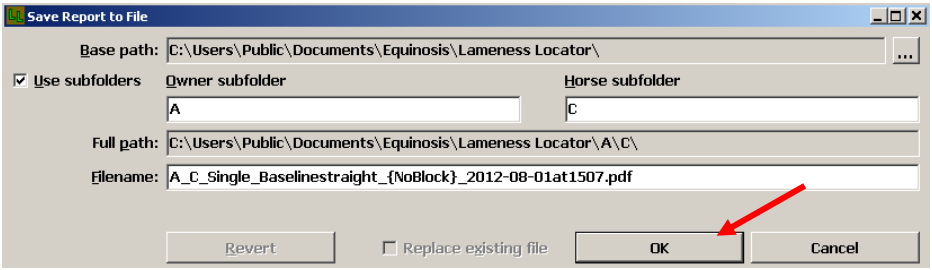
THIRD USER INTERACTION: Displaying the Report

The remaining data analysis will then proceed to completion. The user is not asked to remove outliers in pelvic movement because pelvic vertical movement is will not be erratic; there is little need to remove outliers. After completion of data analysis, the user is asked to save the results. Selecting **YES** will save the results and display the report. Selecting **NO** will discard the results (raw trial data, however, are retained).

FOURTH USER INTERACTION: Saving Report as PDF File

After viewing the report and closing the report window, the **Save Report to File** window will open. The user can save the report as a PDF in the Documents Library of the tablet PC. This will allow the user quick access to reports of a particular horse when needed later or for easy printing or copying of reports to another location, such as is needed with medical records in practice management software. The report file will be generated and named. The name of the file will include the owner last name, horse name, type of report (single, dual or tabular), the trial, block, limb, and date and time of collection. Each report will be saved within a unique and auto-generated owner and horse subfolder in the Documents library. Simply select **OK** to save the PDF file of this report to the Documents Library. To exit without saving in this separate location, select **Cancel**. Note that even if Cancel is selected the report is still

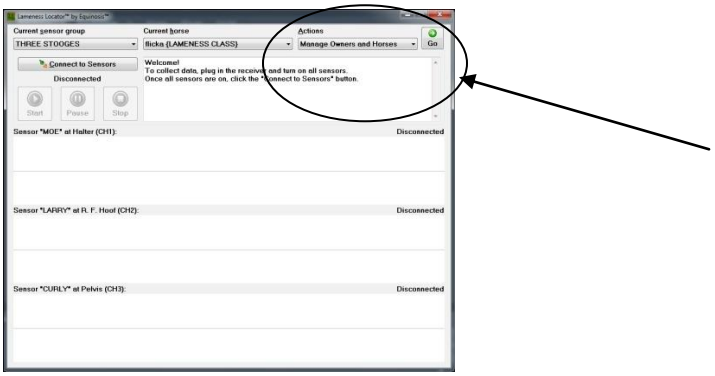
viewable within the Lameness Locator® program. **For easy access, a shortcut of this folder, titled "LL PDF Reports", may have been placed on the desktop of the tablet.**



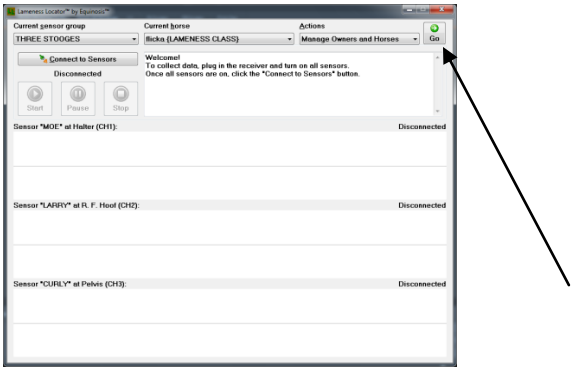
Report Generation of Archived Data (Delayed Data Analysis)

Data analysis can be delayed following data collection, or the user can regenerate analyses on previous collected data (for instance the user may want to re-run the analysis and change the stride selection or remove outliers).

- **Select Manage Horses and Owners** from the **Actions** drop down list. You cannot make selections from the Actions drop down list until the sensors are disconnected.



- Select the **GO** button**.**

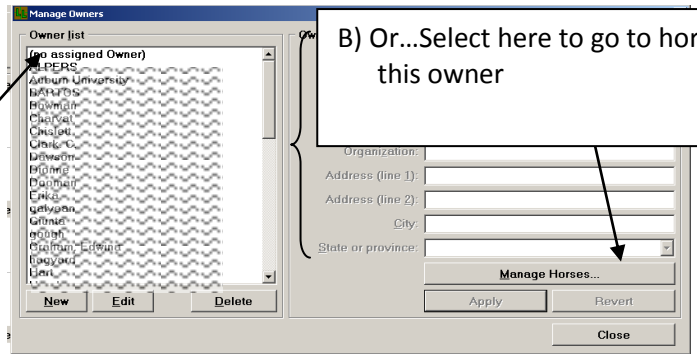


- This brings the user to the **Manage Owners** dialog box. Select the correct owner from the **Owner list**. After selection of the correct owner, the right side of the Manage Owners dialog

box is automatically filled in with the information previously added. To go to the specific horse to be analyzed from that owner, **either A) double-click on the owner's name in the Owner list, or B) select Manage Horses button** (lower right corner of screen).

1) Select the correct owner from **Owner list**

A) double-click to go to horses of this this owner

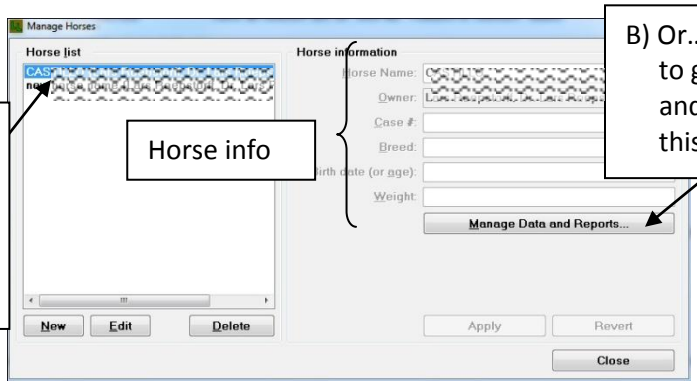


B) Or…Select here to go to horses of this owner

- This brings the user to the **Manage Horses** dialog box. **Select the correct horse from horse list**. After selection of the correct horse, the right side of the Manage Horses dialog box is automatically filled with the information previously added. To go to the trials collected from the horse to be analyzed, **either A) double-click on the horse's name in the Horse list, or B) select Manage Data and Reports button** (lower right corner of screen).

1) Select correct horse from **Horse list**

A) (double-click to go to Data and Reports of this horse)



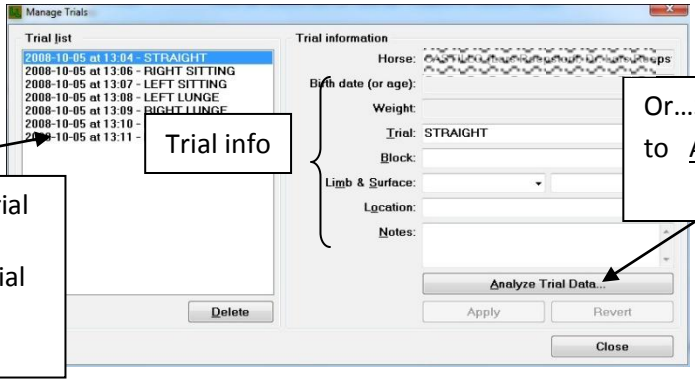
Horse info

B) Or…Select here to go to Data and Reports of this horse

- This brings the user to the **Manage Trials** dialog box. **Select the correct trial from Trial list**. After selection of the correct trial, the right side of the Manage Trials dialog box is automatically filled with the information previously added about the trial at data collection**. Either double-click on the selected trial, or select Analyze Trial Data (lower right corner of screen).**

1) Select correct trial from Trial list

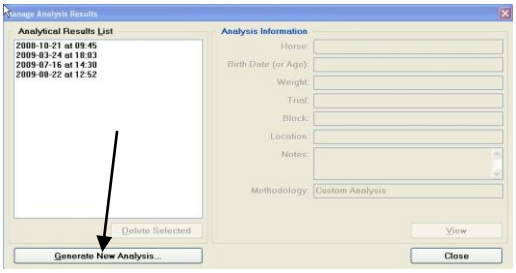
A) double click to Analyze Trial Data



Trial info

Or…Select here to go to Analyze Trial Data

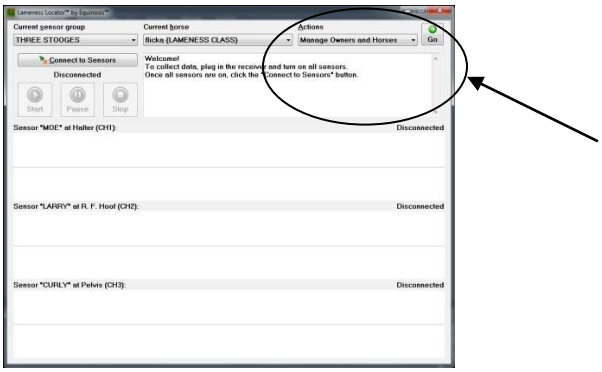
- This will bring the user to the **Manage Analysis Results** dialog box. Select **Generate New Analysis** on the lower left side of the screen, which will launch the analysis.



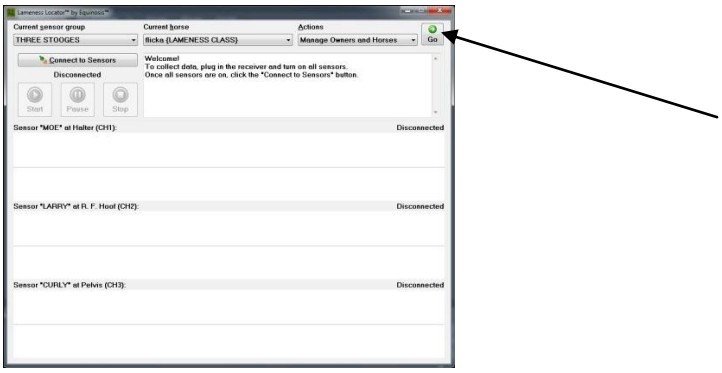
- After selecting Generate New Analysis of the selected trial, data analysis is initiated.

Reviewing Previously-Generated Reports

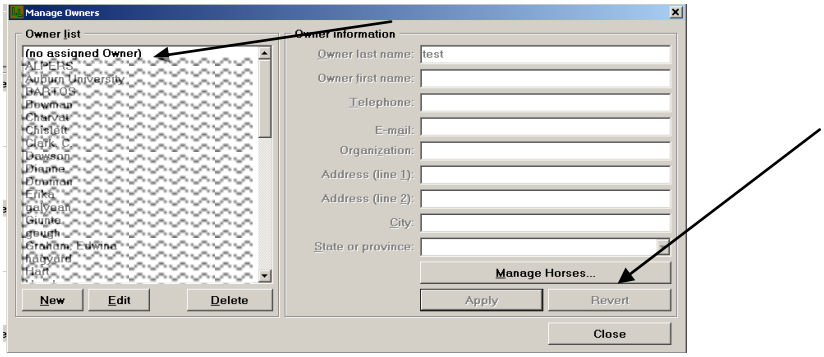
- Open Lameness Locator®.
- Select **Manage Owners and Horses** from the **Actions** drop down list.



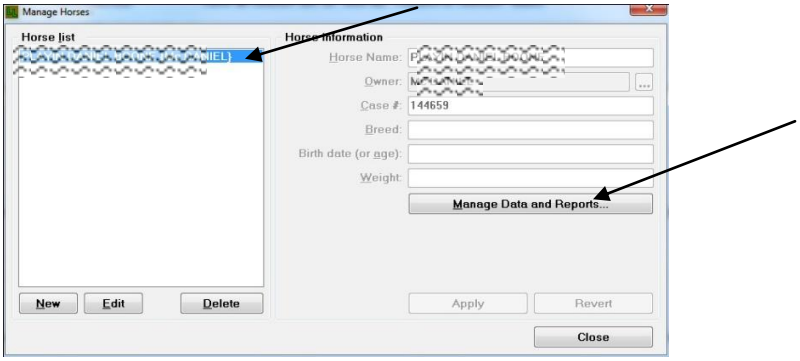
- Select the **GO** button.



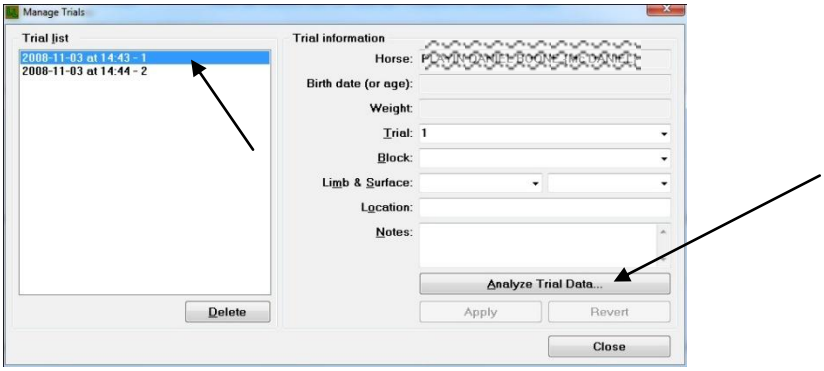
- This opens the **Manage Owners** dialog box. **Select the desired owner by double clicking on the owner's name OR single clicking and then selecting Manage Horses**.



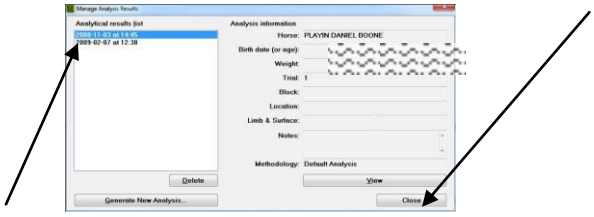
- This opens the **Manage Horses** dialog box. **Select the desired horse by double clicking on the horse's name OR single clicking and then selecting Manage Data and Reports**.



- This opens the **Manage Trials** dialog box. **Select the desired trial by double clicking on the trial OR single clicking and then selecting Analyze Trial Data.**



- This opens the **Manage Analysis Results** dialog box. **To view the report, select a report by double clicking on the desired report, OR single click and select View.**



The Lameness Locator® Report

LAMENESS LOCATOR™ by EQUINOSIS

Analysis Report

Owner, horse and trial specific data

e #: 153081 — Data from: 7/22/2010 at 3:06 PM

se: [redacted] — Owner: [redacted]

l: Baseline straight — Block:

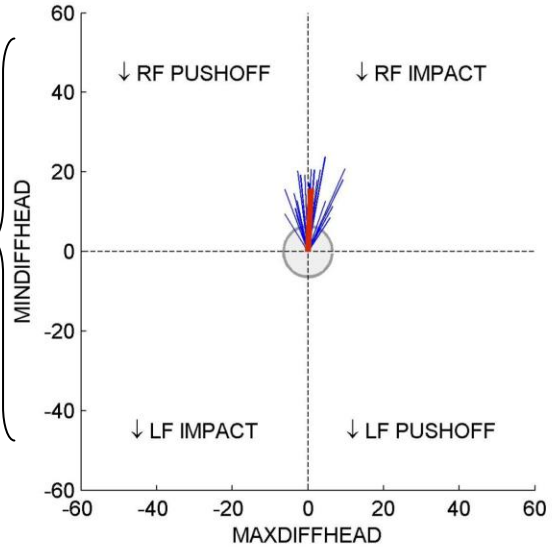
Limb: — Surface: Straight downhill

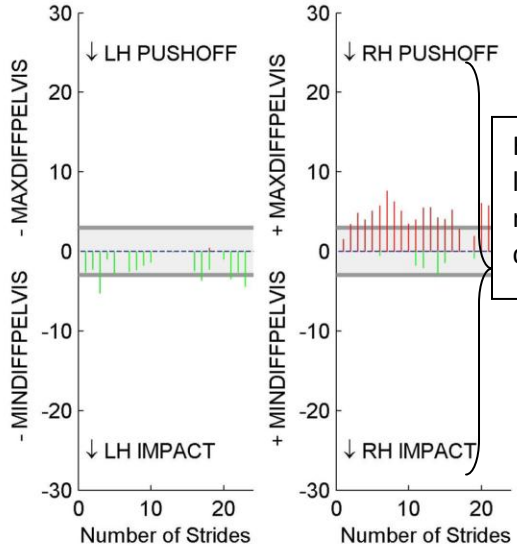
Analysis was performed with default application settings

Stride Rate: 1.382 — **Strides Evaluated (front/hind):** 23 / 23

Front Limb Evaluation — **Hind Limb Evaluation**

Forelimb lameness ray diagram





Hind limb lameness ray diagram

Calculated Lameness values

A1/A2:	**LF:**	0.00	***A1/A2:***	**LH:**	0.0507
Threshold = 0.50	**RF:**	0.7203	***Threshold = 0.17***	**RH:**	0.1306
Head Diff. (mean/s.d.):	**Max:**	0.76 / 4.456	***Pelvis Diff. (mean/sd):***	**Max:**	4.26 / 1.789
Threshold = ±6mm	**Min:**	15.821 / 4.525	***Threshold = ±3mm***	**Min:**	-1.387 / 2.15
Lame Left/Right Front Strides:		0 / 23	**Lame Left/Right Hind Strides:**		9 / 14

Expert System Text and Evaluator Notes Lameness

Evaluator Notes (before and/or after data collection)

There is "no" evidence of left front lameness.
There is "strong" evidence of right front lameness.
There is "no" evidence of left hind lameness.
There is "moderate" evidence of right hind lameness.

Generated with Lameness Locator® 2011 by Equinosis™ — 12/16/2011 at 7:58 AM

Horse Specific Data:

The Lameness Locator® report includes data specific to the owner, horse, and trial entered by the user before data collection. The date that the data was collected (day and time) is reported. Any notes made by the user before or after data collection for the specific trial are reported at the bottom of the Lameness Locator® report.

Ray Diagrams:

The ray diagrams displayed in the Lameness Locator® report give the user a quick, qualitative scan of the lameness detected in the horse. The ray diagram on the left displays the qualitative description of forelimb lameness and the ray diagram on the right displays the qualitative description of the hind limb lameness.

The Forelimb Ray Diagram:

The x-axis is Max Diff Head (the difference in the maximum position of the head after the stance phase of the right front limb compared to the left front limb), with positive values to the right and negative values to the left of the origin in the center. The y-axis is Min Diff Head (the difference in the minimum position of the head during the stance phase of the right forelimb compared to the left forelimb), with positive values above and negative values below the origin in the center. The axes are in mm units. Each blue ray represents one stride. The single thicker red ray in the forelimb ray diagram indicates the mean vector of Max Diff Head and Min Diff Head. The length of each ray is a measure of the amplitude of asymmetry of head motion for that stride. The location of the ray within the quadrants of the ray diagram indicate side, and timing or type of forelimb lameness. Rays in the upper half indicate right forelimb lameness. Rays in the lower half indicate left forelimb lameness. Rays in the upper right quadrant (labeled ↓RF IMPACT) indicate a right forelimb beginning of stance (impact) lameness. Rays in the upper left quadrant (labeled ↓ RFPUSHOFF) indicate a right forelimb end of stance (push off) lameness. Rays in the lower left quadrant (labeled ↓ LF IMPACT) indicate a left forelimb beginning of stance (impact) lameness. Rays in the lower right quadrant (labeled ↓ LF PUSHOFF) indicate a left forelimb end of stance (push off) lameness.

Rays centered on the positive and negative y-axis indicates right forelimb or left forelimb mid-stance lameness, respectively. Rays centered on the positive and negative x-axis are difficult to interpret conclusively. These could indicate either extreme end of stance asymmetry of one limb or early impact lameness of the other limb. Impact lameness is more common in the forelimb than push off lameness. Speeding the horse up may assist in analysis by adjusting the location of the rays within the forelimb ray diagram.

A shaded circle surrounds the axis of the plot, with the radius of the circle representative of the +/- 6 mm threshold of Max Diff Head and Min Diff Head. Note that many rays will fall outside of this threshold area, due to the typical high variability of head movement. However, the thicker red ray indicating the mean vector will allow the user to appreciate whether the mean values of Max Diff Head and Min Diff Head exceed threshold.

Hind Limb Ray Diagram:

The left plot of the hind limb evaluation depicts results for the left hind limb, and the right plot depicts results for the right hind limb. The x-axis of both plots is the number of strides in the entire data set. Each ray is a stride. The rays progress from left to right representing first to last stride in the collected data set. The y-axis in each plot shows Max Diff Pelvis (the difference in the maximum position of the pelvis after the stance phase of the right hind limb compared to the left hind limb) and Min Diff Pelvis (the difference in the minimum position of the pelvis during the stance phase of the right hind limb compared to the left hind limb). The y-axis on the left plot moves from zero at the origin to increasing negative Max Diff Pelvis above the horizontal and from zero at the origin to increasing negative Min Diff Pelvis below the horizontal. The y-axis on the right plot moves from zero at the origin to increasing positive Max Diff Pelvis above the horizontal and from zero at the origin to increasing positive Min Diff Pelvis below the horizontal. The y-axes are in mm units.

Each red plus green ray is a stride. The length of each red plus green ray is a measure of the amplitude of asymmetry of pelvic motion for that stride. The location, color and directions of the rays are representations of the timing or type of hind limb lameness exhibited. Red upward rays in the right plot (labeled ↓RH PUSHOFF) indicate right hind limb push off lameness (less upward thrust of the pelvis after right hind limb push off). Red upward rays in the left plot (labeled ↓LH PUSHOFF) indicate left hind limb push off lameness (less upward thrust of the pelvis after left hind limb push off). Green downward rays in the right plot (labeled ↓RH IMPACT) indicate right hind limb impact lameness (less fall of the pelvis during right hind limb stance). Green downward rays in the left plot (labeled ↓LH IMPACT) indicate left hind limb impact lameness (less fall of the pelvis during left hind limb stance).

A shaded area spanning above and below the origin indicates the +/- 3 mm threshold of Max Diff Pelvis and Min Diff Pelvis. Unlike in the forelimb plot, there is no average (mean vector) indicated in the hind limb plot.

Calculated Lameness Values:

Inspection of the calculated lameness values will give the user a more quantitative description of the forelimb and hind limb lameness. There are two general measures that are reported for both forelimb and hind limb lameness; 1) the A1/A2 ratios, and 2) the maximum and minimum height differences for head and pelvic motion.

The A1/A2 values

A2 can be considered the amount of head or pelvic movement following the center of mass of the body, or the expected, normal movement. A1 can be considered the amount of head or pelvic movement due to lameness. The A1/A2 ratios are general measures of the asymmetry of movement over the entire collected trial. A1/A2 ratio is reported for RF (forelimb lameness attributed to asymmetry in the right forelimb), LF (forelimb lameness attributed to asymmetry in the left forelimb), RH (hind limb lameness attributed to asymmetry in the right hind limb), and LH (hind limb lameness attributed to asymmetry in the left hind limb). As a general rule of thumb, the threshold between soundness and lameness for A1/A2 of the right and left forelimb is ≅ 0.50. A1/A2 forelimb ratios above 0.50 are suspicious of forelimb lameness with an increasing suspicion as the A1/A2 increases. As a general rule of thumb, the

threshold between soundness and lameness for A1/A2 of the right and left hind limb is A1/A2 ≅ 0.17. A1/A2 hind limb ratios above 0.17 are suspicious of hind limb lameness with an increasing suspicion as the A1/A2 increases.

The Max Diff and Min Diff values

Max Diff Head, Min Diff Head, Max Diff Pelvis and Min Diff Pelvis are reported as a mean +/- standard deviation over all analyzed strides. These are specific measures of head and pelvis vertical height asymmetry between the right and left halves of the stride. They are reported in units of millimeters. The Max value is a measure of maximum head or pelvic height difference after the stance phase of the right compared to the left half of the stride. The Min value is a measure of minimum head or pelvic height difference during the stance phase of the right compared to the left half of the stride.

Max Diff Head: The Max Diff Head is a measure of the difference in maximum head height that occurs after right forelimb stance to that which occurs after left forelimb stance. A Max Diff Head greater than +6.0 mm or less than -6.0 mm is consistent with forelimb lameness. A Max Diff Head greater than +6.0 mm may indicate either a right forelimb impact lameness or a left forelimb push off lameness. A Max Diff Head less (more negative) than -6.0 mm may indicate either a right forelimb push off lameness or a left forelimb impact lameness. Side and timing of forelimb lameness is dependent on the amplitude and sign of the **combined** Max Diff Head and Min Diff Head values.

Min Diff Head: The Min Diff Head is a measure of the difference in minimum head height that occurs during right forelimb stance to that which occurs during left forelimb stance. A Min Diff Head greater than +6.0 mm or less than -6.0 mm is consistent with forelimb lameness. A Min Diff Head greater than +6.0 mm may indicate a right forelimb impact, midstance, or push off lameness. A Min Diff Head less (more negative) than -6.0 mm may indicate a left forelimb impact, midstance or push off lameness. Side and timing of forelimb lameness is dependent on the amplitude and sign of the **combined** Max Diff Head and Min Diff Head values.

Max Diff Pelvis: The Max Diff Pelvis is a measure of the difference in maximum pelvis height that occurs after right hind limb stance to that which occurs after left hind limb stance. A Max Diff Pelvis greater than +3.0 mm or less than -3.0 mm is consistent with hind limb lameness. A Max Diff Pelvis greater than +3.0 mm is consistent with a right hind limb push off lameness. A Max Diff Pelvis less (more negative) than -3.0 mm is consistent with a left hind limb push off lameness.

Min Diff Pelvis: The Min Diff Pelvis is a measure of the difference in minimum pelvis height that occurs during right hind limb stance to that which occurs during left hind limb stance. A Min Diff Pelvis greater than +3.0 mm or less than -3.0 mm is consistent with hind limb lameness. A Min Diff Pelvis greater than +3.0 mm is consistent with a right hind limb impact lameness. A Min Diff Pelvis less (more negative) than -3.0 mm is consistent with a left hind limb impact lameness.

Evaluator Notes:

Results of "expert system" evaluations and any user-entered notes will appear at the bottom of the report. See Report Evaluation Assistance below.

Comments on Interpreting the Lameness Locator® Report:

Highly variable data collected from misbehaving or anxious horses will generate results that are less reliable than data collected from well-behaved and cooperative horses. This will be reflected in the amplitudes of the standard deviations of the Head and Pelvic Max Diff and Min Diff values. As a general rule of thumb, it is desirable to collect data such that, in the lame situation, the standard deviations of Head and Pelvic Max Diff and Min Diff are smaller than, or not much larger than, their corresponding means. Conclusions about lameness made on data in which the amplitudes of the standard deviations are much greater than the amplitude of the corresponding means should be considered tentative. By contrast, when the horse is sound (A1/A2 values less than thresholds and Head and Pelvic Max Diffs and Min Diffs within normal range) the standard deviations are expected to be of the same general amplitude or greater than the mean values. Lameness values (A1/A2 ratios, Head and Pelvic Max Diffs and Min Diffs) below threshold may still be significant (i.e. indicate very mild asymmetry) when the standard deviations of the Head and or Pelvic Max Diffs and or Min Diffs are also less than their respective mean values.

MAX AND MIN DIFFS OF HEAD AND PELVIS ARE CONSIDERED TO BE BETTER MEASURES OF FORELIMB AND HIND LIMB LAMENESS THAN THE A1/A2 RATIOS.

Lunging and Flexion Tests

The thresholds reported between soundness and lameness and the 95% confidence intervals for detecting significant change in severity of lameness are valid only after collection of data from a horse trotting in a straight line for at least 25 strides. These thresholds are not valid for trials in which data is collected while the horse is lunging or after flexion tests. The thresholds are not valid during lunging because the horse's torso is tilted toward the inside of the circle, resulting in asymmetric vertical head and/or pelvic movement in many horses. This asymmetric vertical movement is quite dramatic in some normal (sound) horses, yet very mild in others. Asymmetries are greater for lunging circles smaller in diameter. The thresholds are also not valid after flexion tests since the consequences of most flexion tests are evaluated within the first 10 strides as the horse trots off from the examiner after the flexion test. However, Lameness Locator® can still be used to evaluate the horse at the lunge and after flexion tests, and, in some cases (similarly to subjective evaluation), the results of these tests are more beneficial than the results obtained after trotting the horse back and forth in a straight line. The following suggestions are offered as an aid to practitioners using Lameness Locator® to evaluate lameness during lunging and after flexion tests.

Evaluating the Lunge:

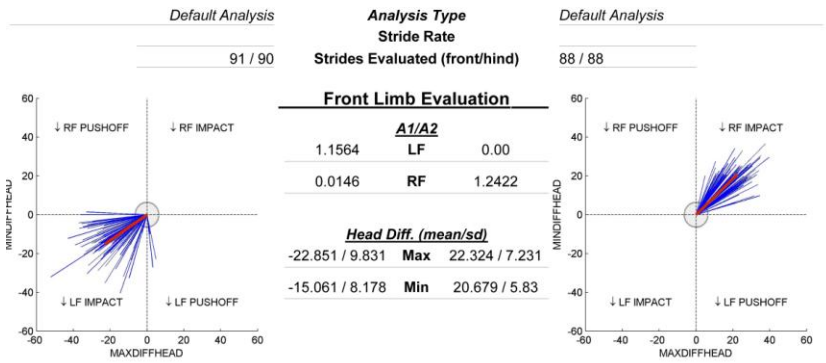
When horses are lunging, especially if lunging in a tight circle, their torso is tilted toward the center of the circle. This creates a potential natural asymmetry in both vertical head and vertical pelvic movement. This asymmetry can be quite dramatic in some horses, even when lameness is not present. However, in the normal horse, the asymmetry should be an expected pattern for that lunging direction Surface on which the horse is lunging influences the expected patterns.

It is important to use Lameness Locator® to evaluate the lunge by comparing lunging in one direction to lunging in the other direction, side-by-side. This can be easily done by using the Dual Report function within Lameness Locator® software (See instructions on generating a dual report below).

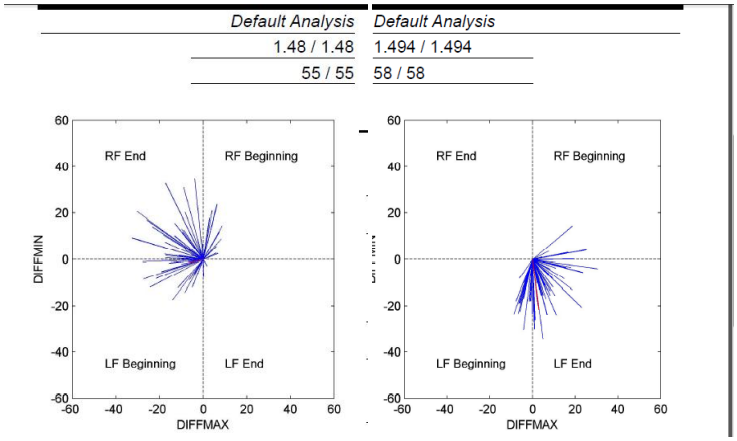
Some normal horses display symmetric vertical movement of head when lunging, while others show quite dramatic asymmetric movement.

On hard surface, an inside forelimb impact asymmetry may be seen. On soft surfaces, an outside forelimb push off asymmetry may be seen (see below).

HARD SURFACE FORELIMB EXAMPLE



SOFT SURFACE FORELIMB EXAMPLE

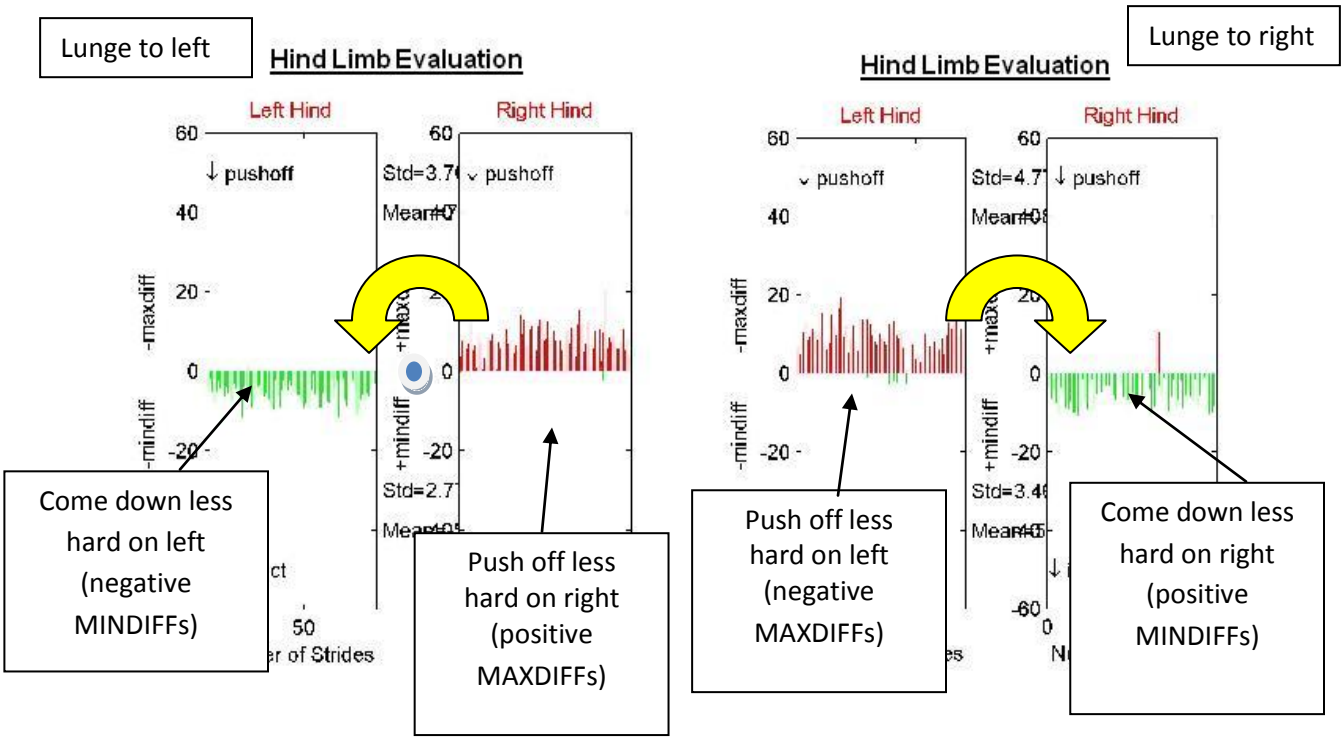


Some normal horses display symmetric vertical movement of the pelvis when lunging, while others show quite dramatic asymmetric movement.

Two commonly seen hind limb patterns in normal horses are shown below.

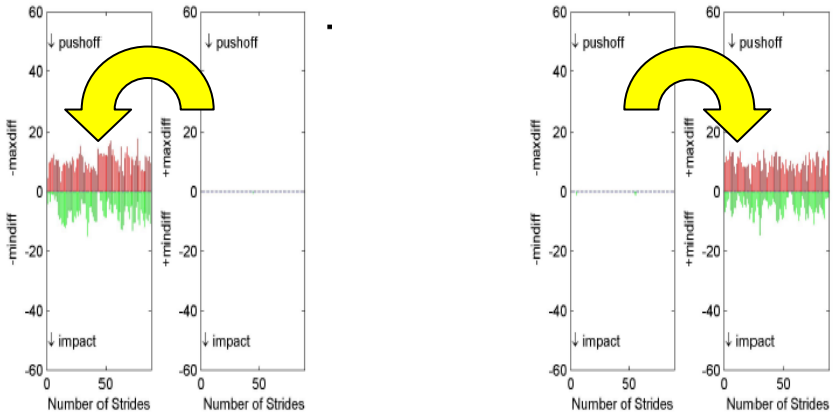
The first commonly seen pattern is less pelvic fall in the inside hind limb and less pelvic rise on the outside hind limb. Thus, a horse, when lunging to the left may have negative Min Diff Pelvis values and positive Max Diff Pelvis values, and when lunging to the right may have positive Min Diff Pelvis values and negative Max Diff Pelvis values. This asymmetry pattern is most commonly seen in soft footing.

In the example below, while lunging to the left, the horse comes down less on the inside hind limb (the left hind limb) and the horse pushes off less on the outside hind limb (the right hind limb). While lunging to the right, this horse does the same but in the opposite limbs as it comes down less on the inside hind limb (the right hind limb) and pushes off less on the outside hind limb (the left hind limb).



The easiest way to remember this common, “expected-normal”, pelvic motion pattern is to imagine a pivot point between the left and right hind limb plots (see above). When lunging to the left rays point to rotate around in a counterclockwise direction, i.e. the same direction of movement as the live horse. When lunging to the right rays point to rotate around in a clockwise direction, i.e. the same direction of movement as the live horse. In one in-depth study, this pattern was seen in 11.7% of normal horses while lunging.

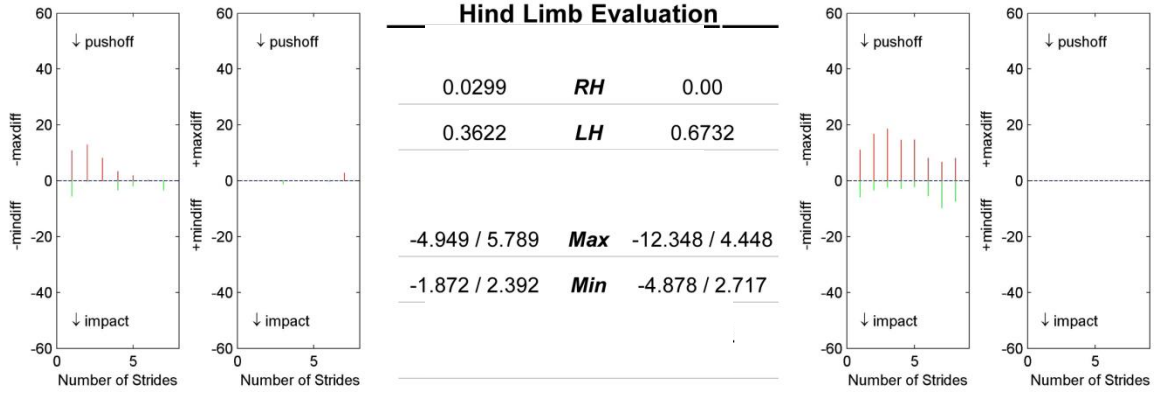
Another commonly seen pattern is less upward and downward movement of the pelvis on the inside hind limb (see below). This pattern is most commonly seen while lunging on harder and firmer surfaces. In one in-depth study, this pattern was seen in 12.5% of normal horses while lunging.



Evaluating Flexion Tests

Lameness Locator® can be used to objectively quantify the effect of flexion tests. **However, the threshold and 95% confidence intervals of the lameness values reported above are not valid for comparison.** A baseline trial, without flexion, of the approximate number of strides as would be evaluated after a flexion test, should first be collected. Most practitioners evaluate the results of the flexion test by observing the horse trotting off away from them for less than 10 strides. So, it is important to collect a baseline trial, without flexion, of the horse trotting off in one direction only for 8-12 strides. **The user can select "Before flexion" from the trial list to identify it separately from a typical straight line trial**. This trial can then be used as the baseline comparison to the post flexion test collections.

For example, below are the hind limb lameness ray diagrams of a horse before (left plot) and after (right plot) a positive left hock flexion test. Before flexion, A1/A2 LH was 0.36 and Max Diff Pelvis was -4.9 mm. After flexion, A1/A2 LH increased to 0.67 and Max Diff Pelvis decreased (absolute value increased) to -12.3 mm.



Comments on Evaluating Change Due to Blocks or Therapy:

The variance of A1/A2 is dependent on the mean. This means that as lameness severity increases or decreases, the amount of change in A1/A2 that can be considered significant will also increase or decrease accordingly. The 95% confidence interval for a significant change in forelimb A1/A2 is 0.31 times the value of A1/A2. The user can assume that a change in forelimb A1/A2 value for RF or LF by >0.31*(A1/A2) after block or treatment will occur randomly (i.e. no affect of block or treatment) only one out of 20 times if the examination were conducted again. The 95% confidence interval for a significant change in hind limb A1/A2 is 0.23 times the value of A1/A2. The user can assume that a change in hind limb A1/A2 value for RH or LH by >0.23*(A1/A2) after block or treatment will occur randomly (i.e. no affect of block or treatment) only one out of 20 times if the examination were conducted again.

The variances of Head and Pelvic Max Diff and Min Diff are not dependent on the mean. This means that as lameness severity increases or decreases, the amount of change in Head and Pelvic Max Diff and Min Diff that can be considered significant is constant. The 95% confidence interval for a significant change in Max Diff Head and Min Diff Head and Max Diff Pelvis and Min Diff Pelvis is +/- 6.0 mm and +/- 3.0 mm, respectively. Therefore, the user can assume that a change in Max Diff Head or Min Mid Diff Head > 6 mm or a change in Max Diff Pelvis or Min Diff Pelvis >3 mm will occur randomly (i.e. no affect of block or treatment) only 1 out of 20 times if the examination were conducted again.

Comments on Compensatory Lameness Patterns:

Primary lameness in the forelimb can cause compensatory (or false) vertical pelvic asymmetry and primary lameness in the hind limb can cause compensatory (or false) vertical head movement asymmetry. Knowledge of these patterns will assist the user in correctly identifying the location of primary lameness.

The compensatory lameness patterns in trotting horses have sometimes been referred to as the “Law of Sides”. According to the “Law of Sides”, a horse with primary hind limb lameness may show

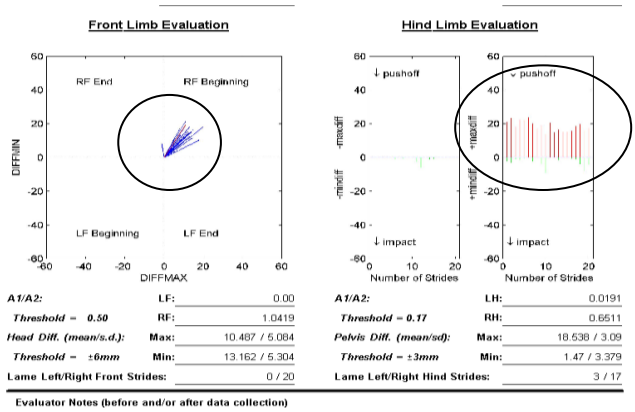
compensatory ipsilateral forelimb asymmetry, and primary forelimb lameness may show compensatory, contralateral hind limb asymmetry. This "Law of Sides" has been tested and reported in many peer-reviewed studies.

The first part of this law, primary hind limb lameness with compensatory (false) forelimb asymmetry is, in many cases, true. The second part of this law, primary forelimb lameness with compensatory (false) hind limb asymmetry, is only half correct.

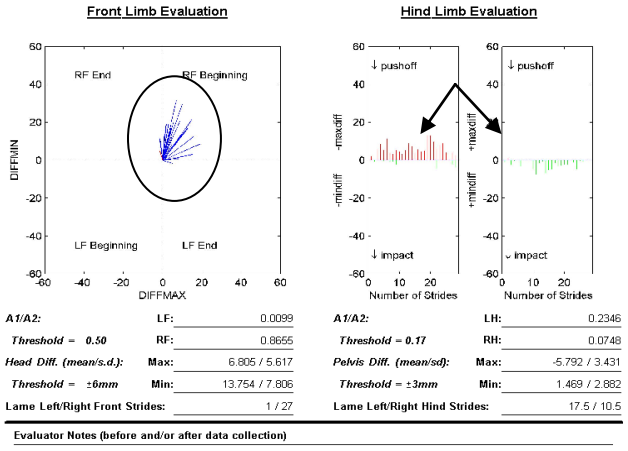
The first part of the "Law of Sides" can be problematic for subjective evaluation of lameness because mild, barely perceptible or even "imperceptible" primary hind limb lameness in some horses will induce a false, compensatory ipsilateral forelimb asymmetry that is more apparent than the primary hind limb lameness. In such a case, attempting to localize a primary forelimb lameness by blocking will be unrewarding. However, because the Lameness Locator® sensors are more sensitive than the naked eye by virtue of their higher sampling rate, this mistake will occur less often.

The second part of the "Law of Sides", stating that an apparent forelimb and contralateral hind limb lameness is most likely a true primary forelimb lameness with a false, compensatory hind limb asymmetry, is only half true. Horses with primary forelimb lameness may have compensatory pelvic movement asymmetries in either or both (ipsilateral and contralateral) hind limbs. Horses with primary forelimb lameness have increased pelvic fall during impact on the contralateral hind limb, thus mimicking less pelvic fall on the ipsilateral hind limb (i.e. an ipsilateral impact asymmetry). They also have increased pelvic rise during push off of the ipsilateral hind limb, thus mimicking less pelvic rise in the contralateral hind limb (i.e. a contralateral push off asymmetry). This complex compensatory pelvic movement rarely causes difficulty in the subjective lameness evaluation since visible pelvic asymmetry is rarely appreciated except in the more severe primary forelimb lameness cases. However, this small pelvic asymmetry can be measured with Lameness Locator® and used as an aid in some cases for correctly identifying forelimb lameness, for example, in highly excitable horses with excessive head tossing unrelated to lameness, when the results of the head sensor motion are too variable for unequivocal evaluation.

Primary Right Hind Limb Lameness with Compensatory Right Forelimb Asymmetry



Primary Right Forelimb Lameness with Compensatory Hind Limb Asymmetry



A1/A2:	LF:	0.0099	*A1/A2:*	LH:	0.2346
Threshold = 0.50	RF:	0.8655	*Threshold = 0.17*	RH:	0.0748
Head Diff. (mean/s.d.):	Max:	6.805 / 5.617	*Pelvis Diff. (mean/sd):*	Max:	-5.792 / 3.431
Threshold = ±6mm	Min:	13.754 / 7.806	*Threshold = ±3mm*	Min:	1.469 / 2.882
Lame Left/Right Front Strides:		1 / 27	Lame Left/Right Hind Strides:		17.5 / 10.5

Evaluator Notes (before and/or after data collection)

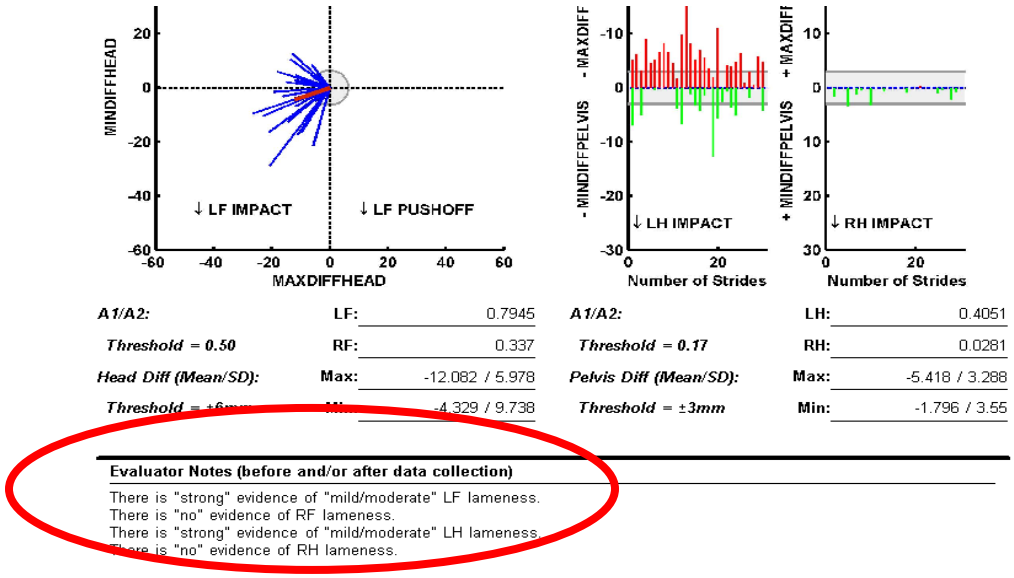
Report Interpretation Assistance (Expert System Assessment):

Lameness Locator 2013 offers users assistance in interpreting the lameness variables under the following conditions; 1) for evaluating a single trial with the horse trotting in a straight line in a single report, 2) for evaluating lunge left and lunge right in a dual report, 3) for evaluating which is the most likely primary limb in a potential multiple limb lameness case in the single report, and 4) for evaluating the effectiveness of nerve and joint blocks in a dual report in a beta test version of a report interpretation assistance feature, called "the expert systems". Result interpretation is offered as a general guide in the notes section at the bottom of the LL report. The user should take into consideration that these "expert systems" suggestions cannot substitute for expert veterinary evaluation. They are generated based on rules developed from experimental observations. Not all horses move following all the rules. These algorithms used in the "expert systems" will likely be further refined over time to enhance sensitivity and accuracy for straight line evaluations the "expert system" require a minimum of 18 strides. For lunging evaluation the "expert system" requires a minimum of 25 strides in each direction. For blocking, the "expert system" requires two straight line evaluations, at least one of which is a trial containing a block. Not every multiple limb lameness situation (more than one limb is measured to have at least weak evidence of a mild lameness) will result in the generation of the multiple limb "expert system"

"Expert System" for Straight line Evaluation:

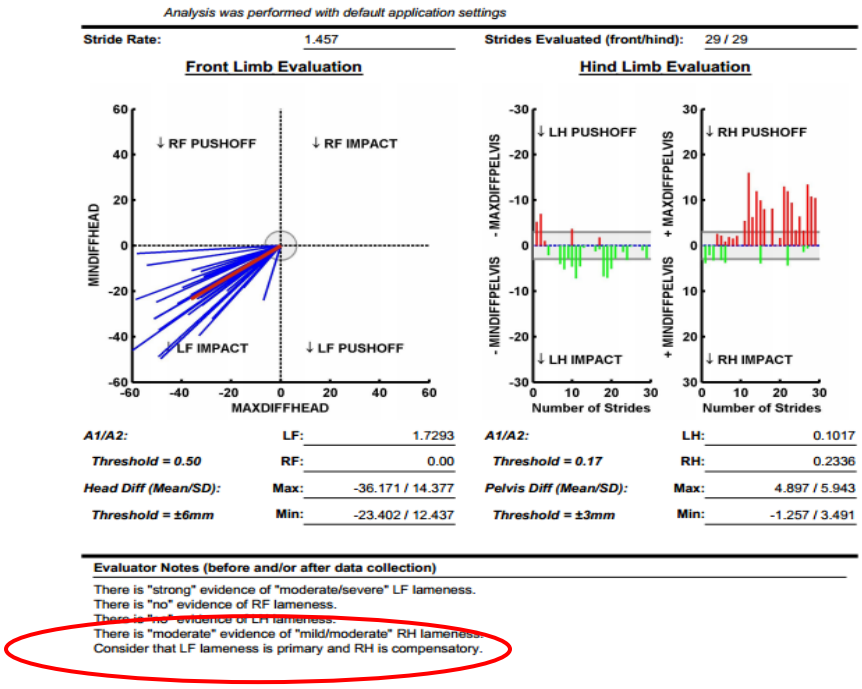
Although a minimum of 25 strides is advised for a good baseline straight data set, a minimum of 18 strides are required to invoke a straight line "expert system" evaluation. Based on criteria related to the A1/A2 ratios, and on the means and standard deviations of the max and min diffs of both the head and pelvis, the "expert system" for straight evaluation will report measures of CONFIDENCE and SEVERITY of lameness for each limb. Measures of confidence indicate how strongly the data indicate lameness in a particular limb, with confidence levels increasing from "no" evidence, to "weak", "moderate", and "strong". Measures of severity indicate amplitude of lameness, with levels increasing from "mild", to "mild/moderate", "moderate", and "moderate/severe". Note: there is no "severe" level

of lameness severity. Each limb is evaluated for confidence and severity of lameness. The "expert system" for straight line evaluation is presented at the bottom of the LL report.



"Expert System" for Potential Compensatory Lameness Patterns:

Depending on circumstances, confidence, amplitude, and distribution (right forelimb, left forelimb, right hind limb or left hind limb impact or push off type lameness) of lameness in a multiple lame limb situation, a multiple limb "expert system" may be invoked indicating which limb is most likely primary. If the multiple limb expert system is not invoked (i.e. amplitude and pattern of lameness variables equivocal) a code (ML1….ML18) will be reported. This is an internal indication that multiple limb "expert system" is functioning properly. Most users can disregard this code.



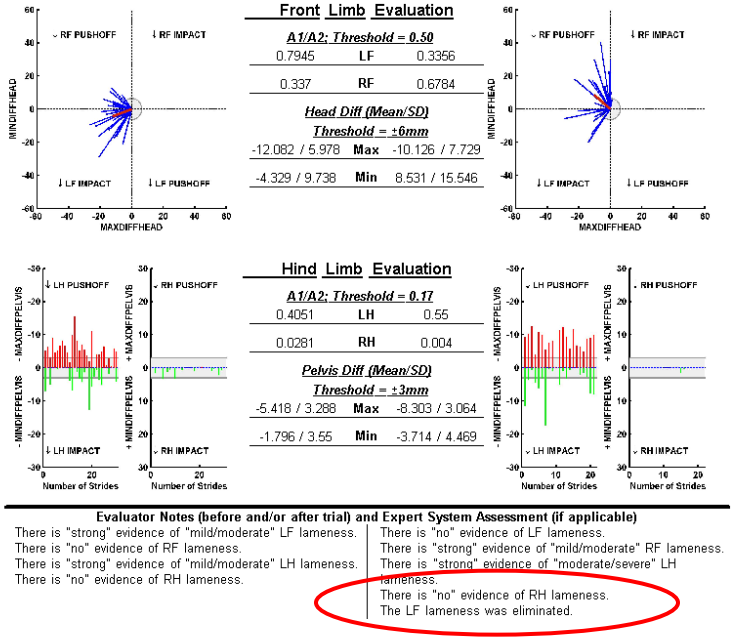
"Expert System" for Lunging Evaluation:

For lunge left compared to lunge right trials **viewed in the dual report only** **(refer to instructions on how to generate a dual report later in this manual)**. Evidence for lameness is either positive or negative for forelimbs and hind limbs (severity of lameness is not assessed). This expert system evaluates the patterns of head and pelvic movement and compares to known normal patterns of sound horses. Known normal patterns are judged to be normal unless the amplitude of asymmetry (head or pelvic) between right and left lunges is significantly different. The direction which displays the lameness during the lunge best is also presented.

"Expert System" for Blocking:

Based on the satisfaction of particular criteria, the system will report the percentage of improvement pre- to post-block on **two straight line trials viewed in the dual report (refer to instructions on how to generate a dual report later in this manual), when at least one of the straight line trials contains a block**. The system is not invoked for comparing blocks in lunging or flexion test trials. **The system is only invoked if the user specifies a limb and a block in the trial set up information, and compares that trial to some previous straight line trial performed on the same day. For best results, the user should compare a blocking trial to the immediately preceding trial in order for appropriate calculation of improvement to be reported.** For instance, if a baseline straight with no block was performed and indicated a LF lameness, followed by a PDN block of the LF, the user would compare these two trials. If after the LF block, the horse then switched to a RF lameness, and the user then performed a PDN block of the RF, the user should compare the RF blocking trial to the LF blocking trial, rather than the original baseline straight.

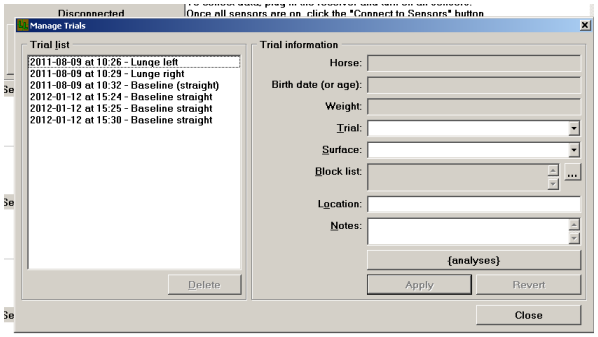
**** NOTE: expert system comments are only invoked if the user utilizes the default Lameness Locator® presets of the straight line trial and blocks. Custom input trial and block options will not invoke expert system comments.



DUAL REPORT FUNCTION

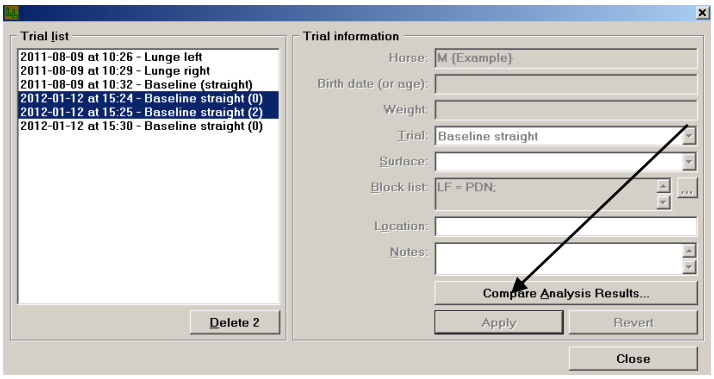
The Dual Reporting function in Lameness Locator® facilitates comparison of evaluations before and after a block, comparing lunging in one direction to the other, and the effects of flexion tests. The user is also able to compare two different reports of the same trial, for instance, if the user generated a new report with outliers removed.

- To create and open a dual report, the user must first display the **Manage Trials** dialog box.

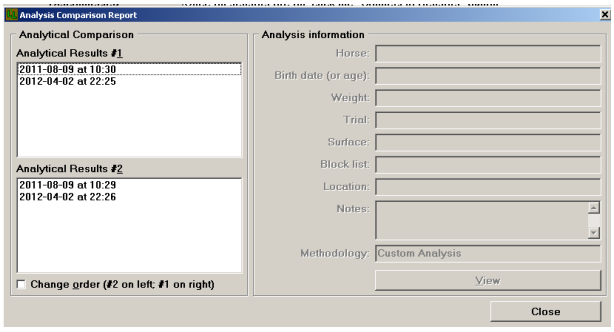


- **Select a first trial** for comparison by single clicking on the desired trial. Note: the first trial selected will be displayed on the left side of the dual report.
- **Select the Ctrl button** on the tablet keypad with the pen stylus

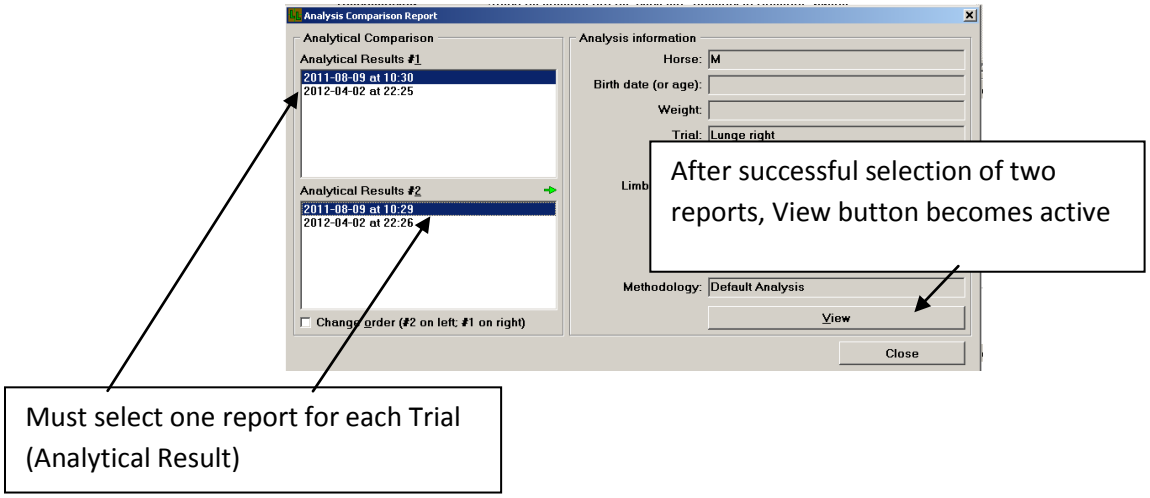
- **Select a second trial** for comparison. Note: the second trial selected will be displayed in the right side of the dual report.
- Once the second trial is selected, the **Analyze Trial Data button changes to Compare Analysis Results.**



- **Select Compare Analysis Results**.
- This opens the **Analysis Comparison Reports** dialog box.

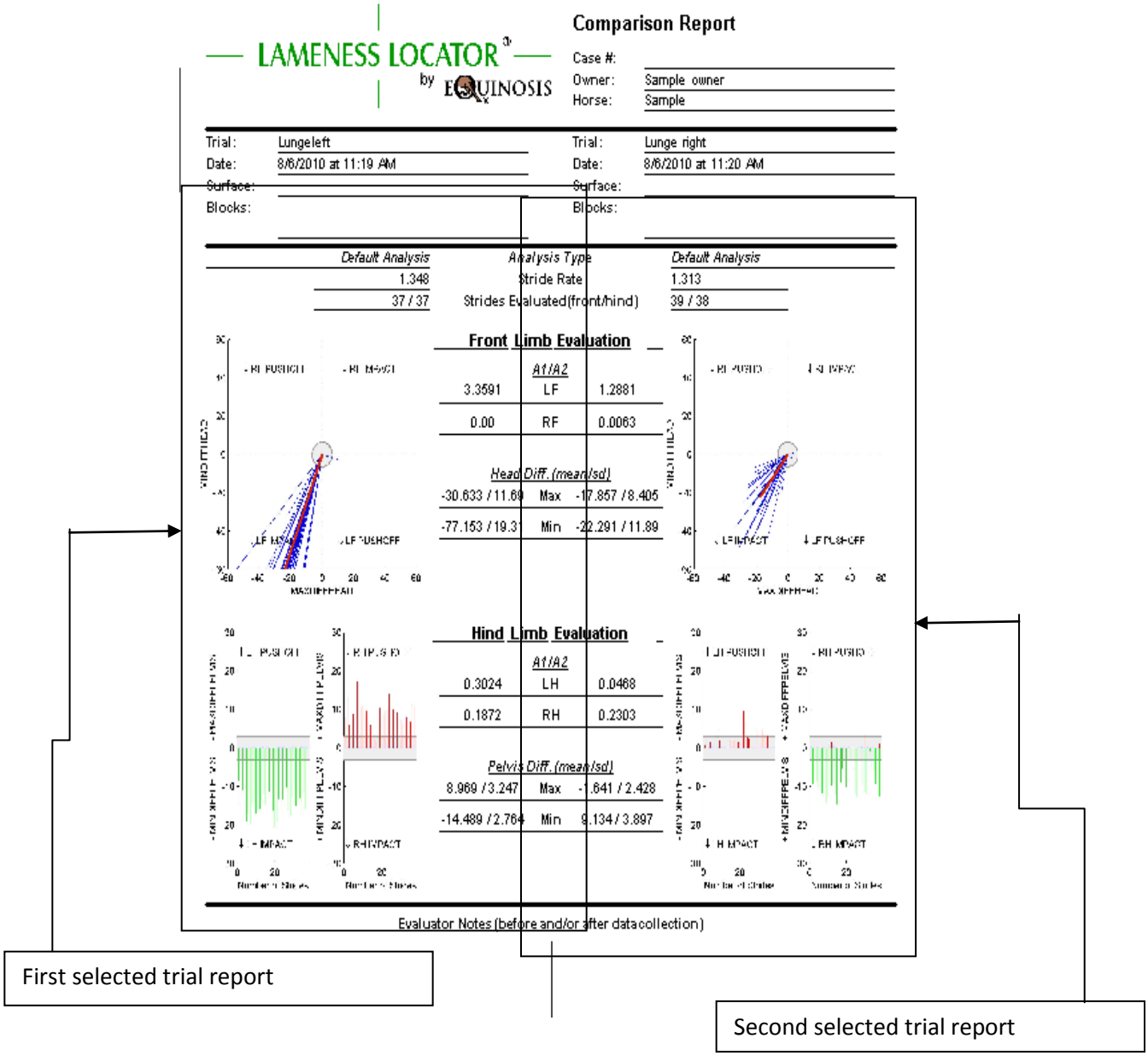


- If more than one report has previously been generated for a specific trial, the user must select by single clicking the desired report to be included. Once selected, the trial to be included will be highlighted in blue. As soon as two reports, one for each trial, have been successfully selected, the View button will be activated.



- Optional: You can change the order of reports by selecting the check box (lower left of window). This will place the first selected report on the right, and the second selected report on the left.
- **Select View** to generate the Dual Report.

All calculated lameness values (A1/A2, Max Diff and Min Diff) are reported for both forelimbs and hind limbs for both trials in the middle of the report side-by-side with the first selected trial on the left and the second selected trial on the right (unless the Change Order box was checked on previous screen). **Remember that thresholds utilized for baseline straight trials are not valid for trials in which data is collected while the horse is lunging or after flexion tests**.



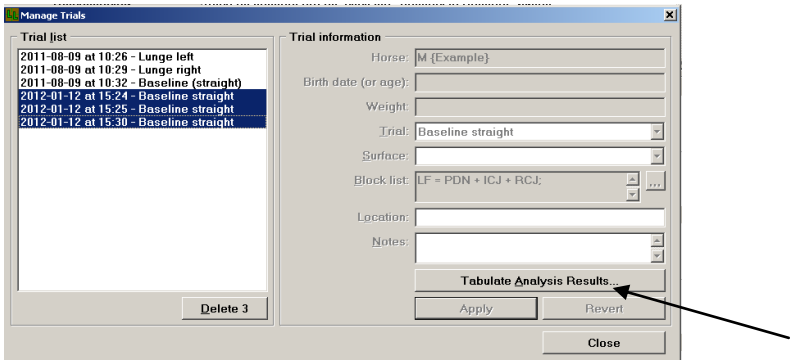
First selected trial report

Second selected trial report

TABULAR REPORT FUNCTION

The Tabular Report function in Lameness Locator® facilitates comparison of evaluations of more than two reports, such as before and after multiple blocks, or comparing the effects of multiple different flexion tests.

- To create and open a tabular report, the user must first go to the **Manage Trials** dialog box.
- **Select a first trial** for comparison.
- **Select the Ctrl button** on the tablet keyboard with the pen stylus
- **Select the subsequent trials** for comparison.



- Once a third trial is selected, the Analyze Trial Data button changes to Tabulate Analysis Results.
- Select as many trials as you would like to view on one report.
- **Select Tabulate Analysis Results**.
- This opens the Analysis Tabulation Report dialog box.
- **Select View** to generate the Lameness Locator® Tabular Report of Multiple Trials. Note that in the tabular reports, the first analysis of any trial is used for comparison.
- **The report will include multiple pages. Use the forward arrow button at the top of the screen to page forward through the report.**

Page 1

by EQUINOSIS

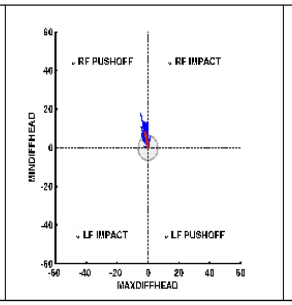
Case #:

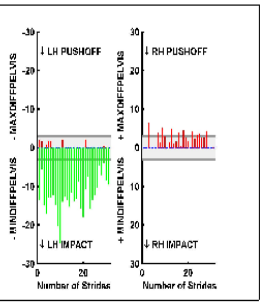
When Trialed	Blocks	Max Diff Head Mean	Max Diff Head SD	Min Diff Head Mean	Min Diff Head SD	Max Diff Pelvis Mean	Max Diff Pelvis SD	Min Diff Pelvis Mean	Min Diff Pelvis SD
Baseline straight 12/13/2012 at 10:29 A		-1.891	1.585	8.504	3.98	1.687	2.504	-12.496	4.465
Baseline straight 12/13/2012 at 10:56 A	LH = LatPlt;	-2.098	1.756	-0.085	1.799	2.394	2.159	0.087	2.469
Baseline straight 12/13/2012 at 11:00 A	LH = LatPlt;	-0.957	2.055	0.299	1.703	0.846	2.311	-0.348	2.165

Trial information and calculated lameness variables

Baseline straight

12/13/2012 at 10:29 A



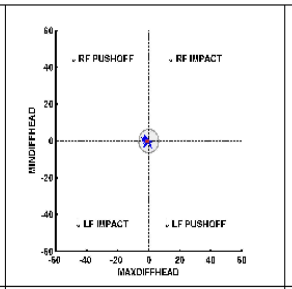


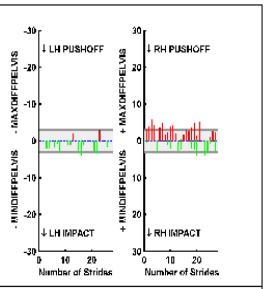
Page 2

Baseline straight

12/13/2012 at 10:56 A

LH = LatPlt;

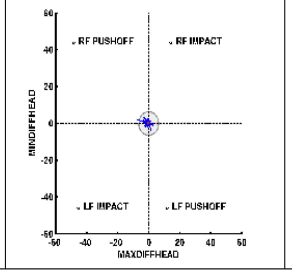


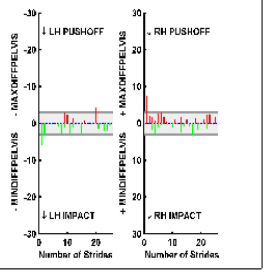


Baseline straight

12/13/2012 at 11:00 A

LH = LatPlt;





Trial Information and ray diagrams

DATA BACKUP

With frequent and regular backup all previously collected data can be reinstalled on your LL system in the unlikely event of a hard drive crash or other system configuration malfunction.

Lameness Locator® now employs a semi-automatic back up USB drive that can remain inserted in the tablet computer at all times. A scheduled back up of the Lameness Locator program will occur automatically every Monday at 1AM, as long as the tablet is left plugged in and turned on. Should you miss a scheduled back up, you will be prompted to back up your data upon your next start up of Lameness Locator®. You can run a back up in the background, and will not be prohibited from utilizing the program.

Additionally, you can always run a manual back up, if you choose to back up your data more frequently than weekly.

TO RUN A MANUAL BACK UP OF LAMENESS LOCATOR® RAW DATA FILES USING THE EQUINOSIS USB BACK UP DRIVE:

- Be sure the Equinosis USB backup drive is inserted into one of the USB ports of the tablet.
- Open Lameness Locator.
- Select **Archive Data For Export** from the **Actions Drop Down** Menu.
- Export data window will open.
- Check the "archive data to external Equinosis drive".
- Select "Export Data". Data will be compressed into a zipped file.
- When the backup is completed an "Export Succeeded" message will appear in the window next to the "Export Data" button. Select **Close.**

TO RUN A MANUAL BACK UP OF LAMENESS LOCATOR® RAW DATA FILES USING A NON-EQUINOSIS USB BACK UP DRIVE:

- Insert USB memory stick/drive into one of the USB ports of the tablet.
- Open Lameness Locator.
- Select **Archive Data For Export** from the **Actions Drop Down** Menu.
- Export data window will open.
- Leave the "archive data to external Equinosis drive" UNCHECKED.
- Check "allow renaming or moving the copy of the exported data file".
- Select "Export Data". Data will be compressed into a zipped file.
- Upon completion, a "Copy Exported Data File As…" window will open. For your convenience you can rename the auto-generated file to something you will easily recognize, such as "LLbackup01.12.12.7z". **You must include the ".7z" file extension**.
- Select where you would like to put the folder from the column on the left. Scroll down to locate the USB drive (D:) and select, then SAVE.
- When the backup is completed an "Export Succeeded" message will appear in the window next to the "Export Data" button. Select **Close.**

User Manual Appendix

Examples of Report Interpretations

EXAMPLES OF VARIOUS LAMENESS AND TIPS TO KEEP IN MIND WHEN INTERPRETING THE REPORT

When reviewing LL Report data, it is helpful to consider a "four strike" approach.

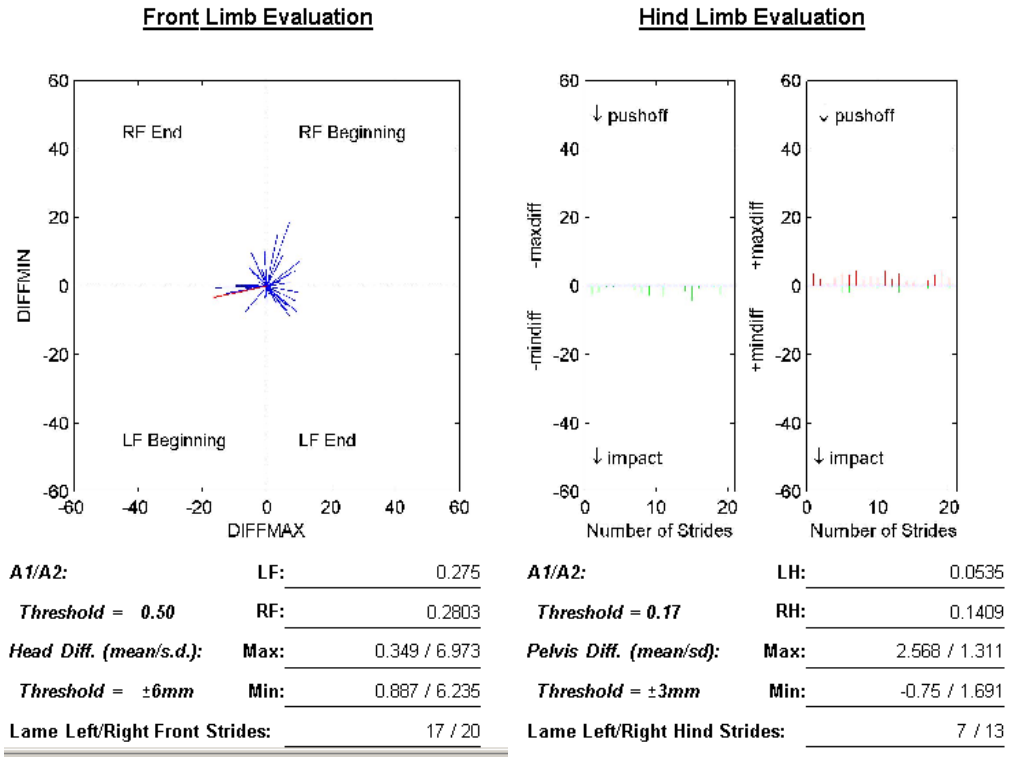
1) Consider using a "four strike rule".
    a. For the forelimb:
        i. Inspect the ray diagram. Is there an accumulation of rays in any particular direction or quadrant, such as LF impact or RF push off? If yes, that's ***strike one***.
        ii. Check the A1/A2 ratios for the LF and the RF. Is either greater than 0.5? If yes, that's ***strike two***.
        iii. Check the Max Diff Head and Min Diff Head mean values (the mean value is first to the left of the slash (/). Is the absolute value of either or both greater than |+/- 6| mm? If yes, that's ***strike three***.
        iv. If either or both Max or Min mean values are elevated, is the standard deviation, which is the second number to the right of the slash (/), less than the mean value? The standard deviation provides a measure of data variability. Standard deviations greater than their respective means indicate that the data is not very consistent. If the standard deviation is less than the respective mean, this indicates that the data is consistent and reliable. If the standard deviation is less than the respective mean, that's ***strike four***.
    b. For the hind limb:
        i. Inspect the ray diagram. Is there an accumulation of rays (green down or red up) in any particular direction or quadrant? If yes, that's ***strike one***.
            1. Left hind push off asymmetry/lameness = red rays up on left
            2. Left hind impact asymmetry/lameness= green rays down on left
            3. Right hind push off asymmetry/lameness= red rays up on right
            4. Right hind impact asymmetry/lameness = green rays down on right
        ii. Check the A1/A2 ratios for the LH and the RH. Is either greater than 0.17? If yes, that's ***strike two***.
        iii. Check the Max Diff Pelvis and Min Diff Pelvis mean values. Is the absolute value of either or both greater than |+/-3| mm? If yes, that's ***strike three***.
        iv. If either or both Max or Min mean values are elevated, is the standard deviation less than its respective mean value? If the standard deviation is less than the respective mean, this indicates that the data is consistent and reliable. If the standard deviation is less than the respective mean, that's ***strike four***.

Four strikes is a strong indicator of consistent asymmetry for a particular limb, which in turn is consistent with either primary or compensatory lameness for that limb. Two to three strikes may still be evidence of asymmetry and lameness, but the evidence is weaker. Less than 4 strikes may, on one hand, indicate more subtle or milder asymmetry but true lameness, or, on the other hand, increased variability of data, making the determination of lameness less reliable. Inspecting the standard deviations assists the user in these situations (less than 4 strikes). For

example, one might observe rays concentrated in the “LF beginning of stance” quadrant, an elevated LF A1/A2 ratio of 0.8, but the Max Diff Head and Min Diff Head are both below the threshold of |+/- 6| mm, for example 4.0 and 5.8 mm, respectively. In a situation where the horse was presented for evaluation of lameness or decreased performance, as opposed to, for example a pre-purchase evaluation, this data may still be useful for deciding which limb to further investigate. If the standard deviations are less than the mean values, despite the mean values being below the threshold, i.e. a three strike situation, this may be indicative of a subtle yet consistent asymmetry or lameness. Alternatively, in the situation of a mean Max Diff Head and or mean Min Diff Head above threshold, but with high standard deviations (higher than the mean values), the data may be too variable to make a strong case for lameness. Perhaps the horse was acting up, tossing its head, etc. Measures to decrease variability, like collecting additional trials or mildly sedating the horse (0.1 cc Dormosedan) before collecting more data, may be beneficial to generate more consistent results.

*It is important to reiterate that users **should not look only** at the left and right A1/A2 ratios for determination of lameness. A1/A2 ratios are gross measures of the entire collected trial. The user **should inspect** both Max Diff and Min Diff mean values as part of a complete evaluation. Mean Max Diff and Min Diff values are more sensitive indicators of lameness, which indicate timing of peak pain within the stride, and along with their respective standard deviations, indicate the variability of the dataset - something that A1/A2 values do not provide.*

An example of data from a horse with symmetric movement in both front and hind limbs.

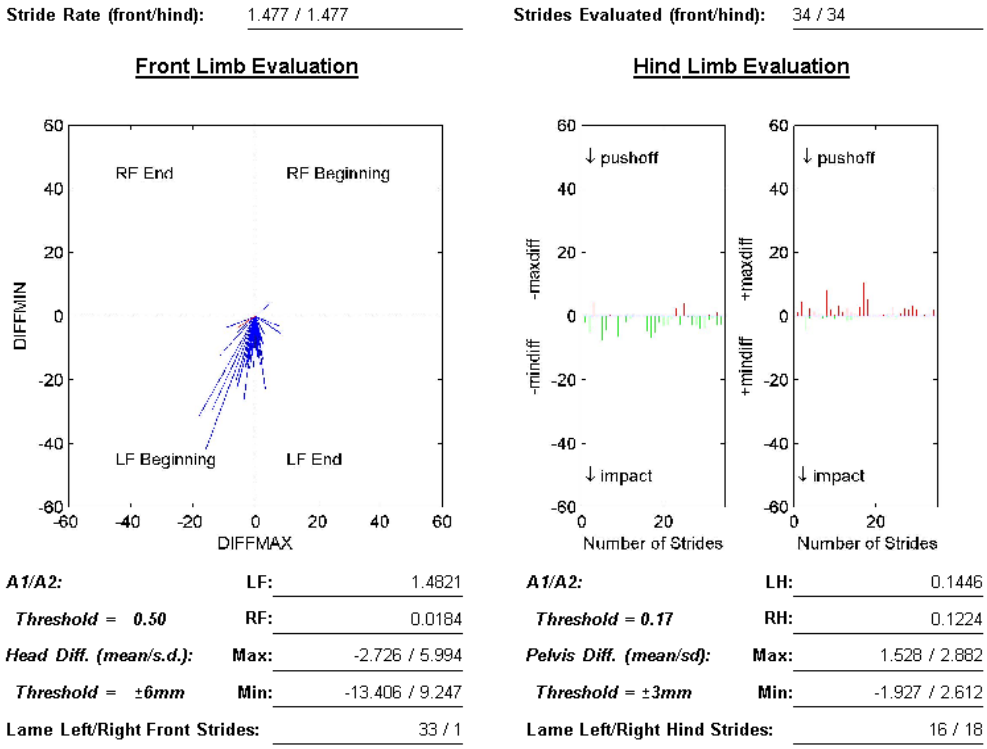


Forelimb evaluation:
There is a characteristic “starburst” pattern in the forelimb ray diagram of a normal (sound) horse, without an accumulation of rays in any particular direction or quadrant.
A1/A2 ratios are less than 0.5 for both LF and RF.
Max Diff Head (0.3) is below threshold of |+/-6| mm.
Min Diff Head (0.8) is below threshold of |+/-6| mm.
Standard deviation of Max Diff Head is 6.9 mm, substantially greater than its mean (0.3 mm).
Standard deviation of Min Diff Head is 6.2 mm, substantially greater than its mean (0.8 mm).
So, there are ***0 strikes*** for the forelimb evaluation.

Hind limb evaluation:
There are short green rays down on the left indicating slight decreased impact in the left hind limb and short red rays up on the right indicating slight decreased push off in the right hind limb.
In this case is would be reasonable to assign ***1 weak strike*** to each hind limb.
However, the LH and RH A1/A2 ratios are both less than 0.17. ***No strike***.
Max Diff Pelvis (2.5 mm) is below threshold of |+/- 3 mm|. ***No strike***.
Min Diff Pelvis (-0.75 mm) is below threshold of |+/- 3 mm|. ***No strike***.

This evaluation should be considered within normal limits.

An example of data from a horse with LF lameness on the straight and during lunging.



Forelimb evaluation:

There is an accumulation of rays pointing straight down in the forelimb ray diagram. Since the rays are centered near the negative Y axis, this is indicative of a LF midstance lameness. ***Strike 1*** for the LF**.**

LF A1/A2 ratio (1.48) is above threshold of 0.5. ***Strike 2*** for the LF.

Min Diff Head (-13 mm) is above threshold of |+/- 6| mm, with a standard deviation (9.2 mm) less than the mean. ***Strikes 3 and 4*** for the LF.

As a review, the Max Diff Head is plotted on the x-axis (with positive values to the right and negative numbers to the left of the origin). Min Diff Head values are plotted on the y-axis, with positive values above and negative numbers below the origin. In lameness with peak pain near midstance, such as is evident in the above case, Min Diff Head is predominantly affected. Max Diff Head is not affected and is close to zero.

Hind limb evaluation:

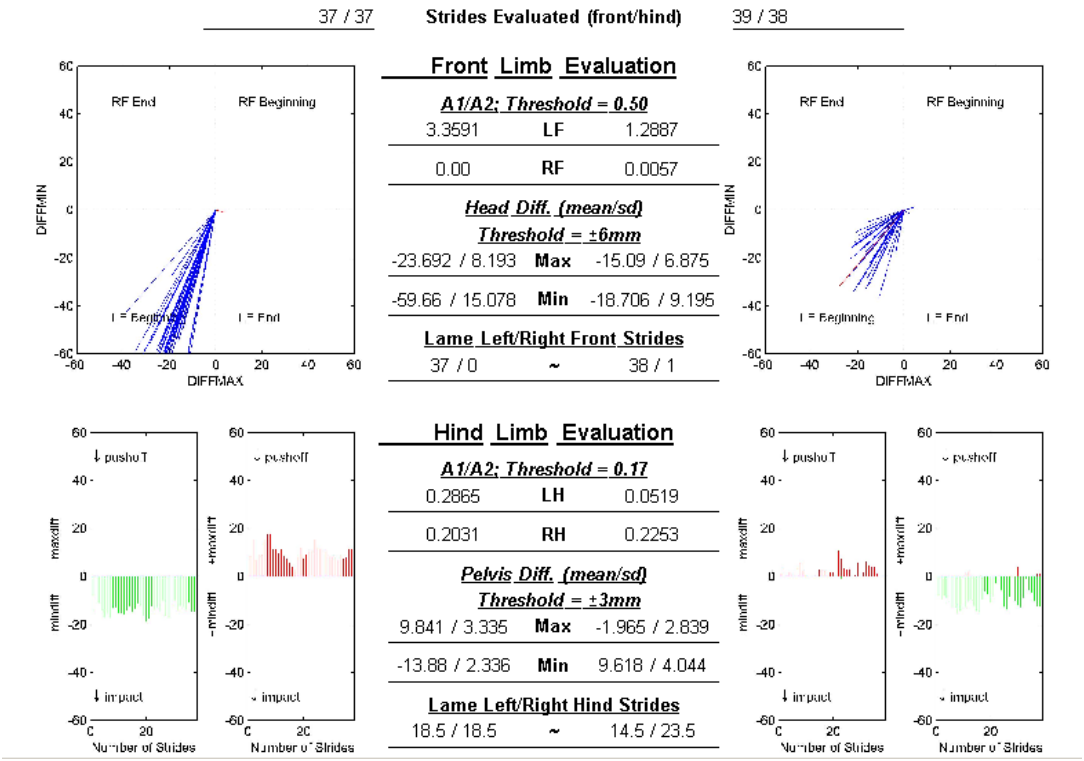
Short green rays pointing down and short red rays pointing up are visible on the left and right, respectively. In this case is would be reasonable to assign ***1 weak strike*** to each hind limb.

However, the LH and RH A1/A2 ratios are both less than 0.17. ***No strike***.

Max Diff Pelvis and Min Diff Pelvis below threshold. ***No strike***.

This hind limb evaluation should be considered within normal limits.

Below is the lunging data for this horse, with circle left on the left and circle right on the right.



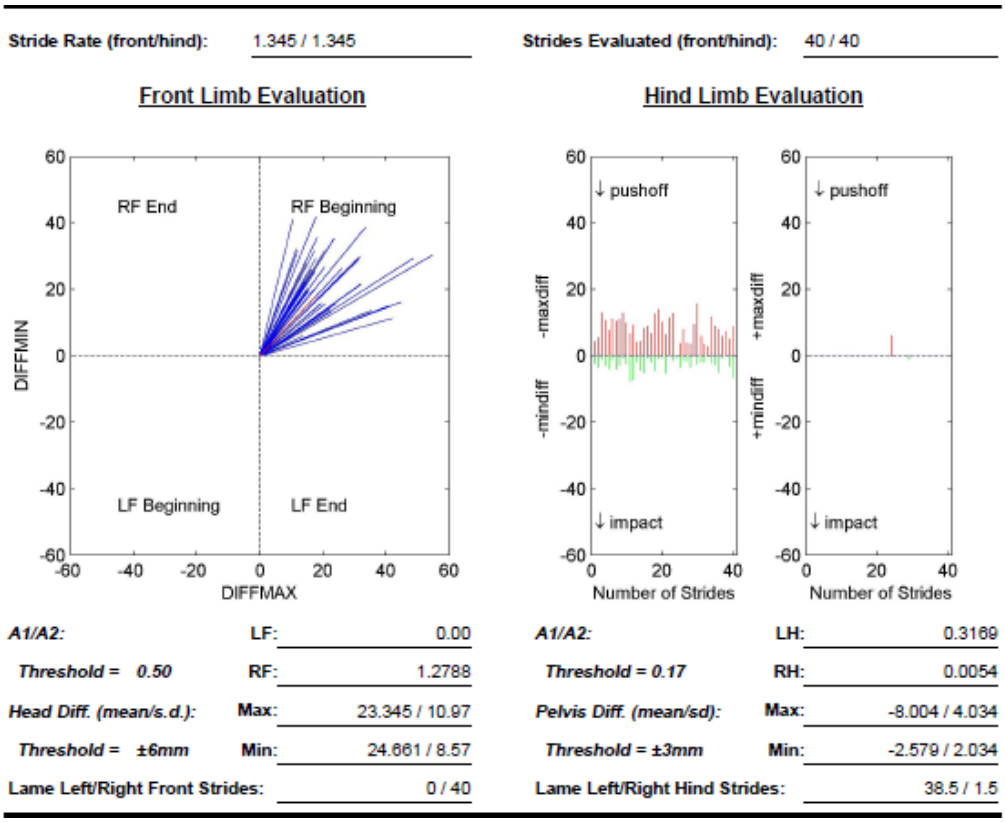
It is important to evaluate lunging in one direction always as a simultaneous comparison to lunging in the other direction. Evaluating lunging in one direction in a separate single report is not useful and is not recommended. Thresholds between normal and abnormal (sound and lame) reported by Lameness Locator® were determined by trotting horses in straight lines and analyzing at least 25 strides. These thresholds ***do not hold*** for data collected while the horse is lunging. This is because many horses lunge with the torso tilted substantially towards the center of the circle, which frequently results in head and pelvic movement asymmetry between left and right halves of the stride. However many horses lunge with equivalent torso tilt in one direction compared to the other and, in horses that are trained to lunge, head and pelvis movement asymmetry will be “equal in amplitude” but “opposite in direction” while lunging in opposite directions. Also, research with lunging horses using this equipment has determined that certain patterns of movement are common in normal horses and that the acceptable patterns for normal horses are somewhat dependent on “hardness” of ground. Data collected while the horse is lunging is best evaluated by simultaneous comparison of the ray diagrams and lameness values resulting from lunging in one direction to that resulting from lunging in the other direction.

On hard ground, such as asphalt, it is not uncommon for normal horses to exhibit head movement asymmetry that mimics ***inside forelimb impact*** (beginning of stance) lameness and to exhibit pelvic movement asymmetry that mimics ***inside hind limb impact*** (beginning of stance) ***and push off*** (end of stance) lameness.

On soft ground, such as sand, it is not uncommon for normal horses to exhibit head movement asymmetry that mimics ***outside forelimb push off*** lameness and to exhibit pelvic movement asymmetry that mimics ***inside hind limb impact and outside hind limb push off*** lameness.

Lunging data in the above case indicates LF lameness while lunging in either direction, with exacerbation of LF lameness while lunging to the left. Hind limb results display a common patterns that are "equal and opposite" when comparing lunging in one direction to lunging in the other direction. Note that while lunging to the left, left hind (inside hind limb) impact and right hind (outside hind limb) push off asymmetries are displayed. Similarly for lunging to the right, right hind (inside hind limb) impact and left hind (outside hind limb) push off asymmetries are displayed. This is a common pattern in normal horses while lunging. The ray diagrams from lunging in opposite directions are "mirror images" of each other. In this particular case, the amplitudes of push off asymmetries between the two lunging directions are not equal; however, the significant LF lameness may be contributing to compensatory movements in the pelvis. The most significant lameness in this case is the LF.

An example of data from a horse with RF and LH lameness.

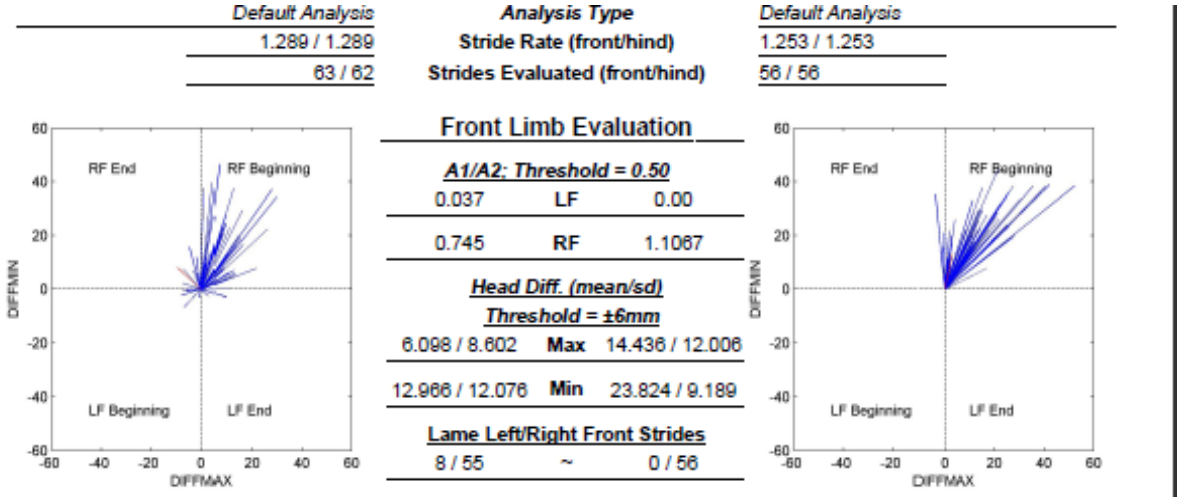


Forelimb evaluation:
There is an accumulation of rays pointing in the “RF Beginning” quadrant, indicative of a beginning of stance or impact lameness in the RF. ***Strike 1*** for the RF.
RF A1/A2 is 1.27, above the threshold of 0.5. ***Strike 2*** for the RF.
Mean Max Diff Head is 23.3 mm and mean Min Diff Head is 24.6 mm, both higher than the threshold of |+/- 6| mm. ***Strike 3*** for the RF.
The standard deviation of Max Diff Head (10.97) and Min Diff Head (8.57) are both smaller than their respective means. ***Strike 4*** for the RF.

Hind limb evaluation:
There is a preponderance of red rays pointing up on the left. This indicates LH push off type lameness, i.e. the horse is not pushing off the left hind limb as hard as it is pushing off the right hind limb. ***Strike 1*** for the LH.
LH A1/A2 ratio (0.31) is elevated above the threshold of 0.17. ***Strike 2*** for the LH.
Mean Max Diff Pelvis (-8.0 mm) is above the threshold of |+/- 3| mm. ***Strike 3*** for the LH.
Standard deviation of Max Diff Pelvis (4 mm) is less than its corresponding mean. ***Strike 4*** for the LH.

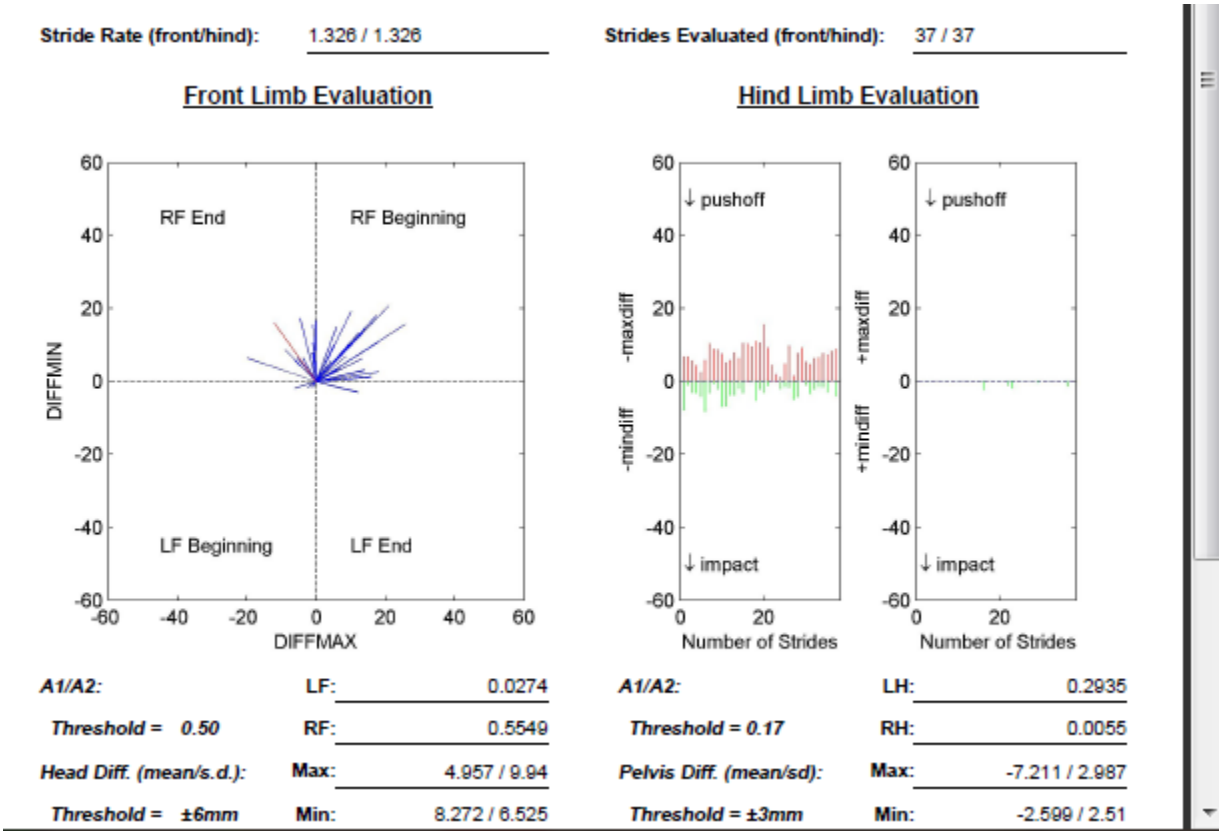
This evaluation has four strikes against a RF (impact type) and four strikes against LH (push off type) lameness. The horse either has 2 limbs that are lame, the RF and the LH, or the horse has a primary RF lameness with compensatory contralateral push off lameness in the opposite hind limb. Further evaluation of the horse is needed to differentiate.

Forelimb lameness evaluation while the horse was lunging is shown below, with lunging to the left on the left and lunging to the right on the right.



The first thing one notices is that the forelimb ray diagram on the left does not have a preponderance of rays pointing in the opposite direction as the forelimb ray diagram on the right. Comparing between lunging to the left and lunging to the right, the length of the rays may be approximately equal in amplitude but they are not pointing in opposite directions. Instead there is an accumulation of rays pointing in the "RF Beginning" quadrant for both lunging to the left and lunging to the right. This is a strong indication of a true RF lameness.

The horse was re-evaluated at a straight line trot after a RF PDN block, resulting in the analysis below.



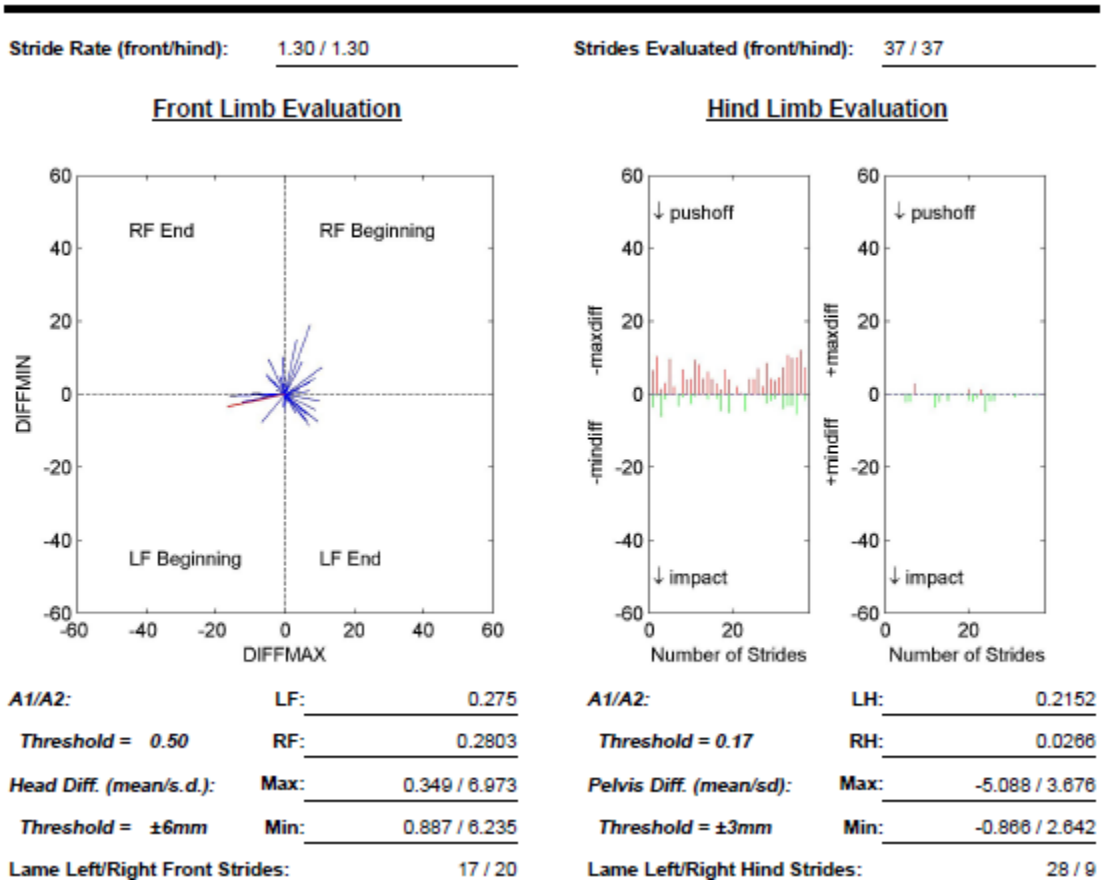
Notice the rays in forelimb ray diagram are shorter. In addition, more rays are pointing in the "RF End" quadrant than before block. There is still lameness in the RF but of less severity.

The RF A1/A2 ratio has decreased from 1.2 before block to 0.55 after block - a decrease, or improvement, of greater than 50%.

Mean Max Diff Head decreased from 23.3 mm before block to 5.0 mm after block - a decrease, or improvement, of 18 mm - greater than 75%. Mean Min Diff Head decreased from 24.6 mm before block to 8.3 mm after block - a decrease, or improvement, of 16 mm - greater than 66%. This is an indication of significant improvement after PDN block and strong evidence for the location of lameness.

The LH is relatively unchanged indicating that the LH lameness is a real and potential completely separate issue, and not due to compensatory movement due to the primary forelimb lameness.

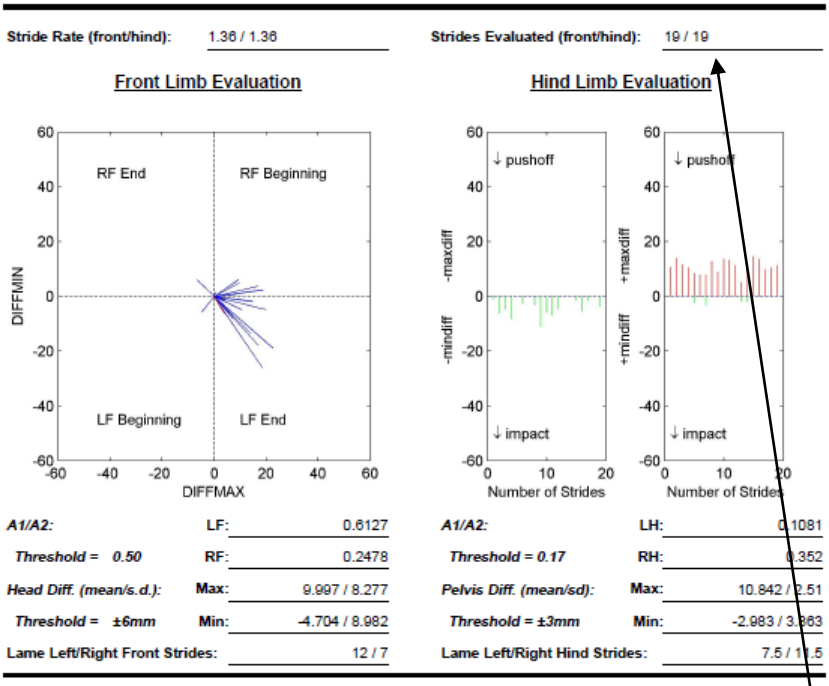
The horse was re-evaluated after a RF abaxial sesamoid nerve block, with the following analysis results.



The horse now exhibits the classic “starburst” pattern in the forelimb ray diagram that is common in horses that are not lame. In addition the RF and LF A1/A2 ratio are both below the threshold of 0.5 and the Max Diff Head and Min Diff Head are both below the threshold of |+/- 6| mm. Because the mean Max Diff Head and Min Diff Head are now small, the standard deviations of Max Diff Head (7.0) and Min Diff Head (6.2) are greater than their corresponding means. Low Max Diff Head and Min Diff Head mean values with relatively higher standard deviations is typical for horses with generally symmetrical movement, i.e. are not lame.

After the resolution of the right front lameness, the left hind limb lameness is still measurable. This is a secondary lameness and is not compensatory for the forelimb lameness.

An example of data from a horse with RH lameness on the straight and during the lunge.



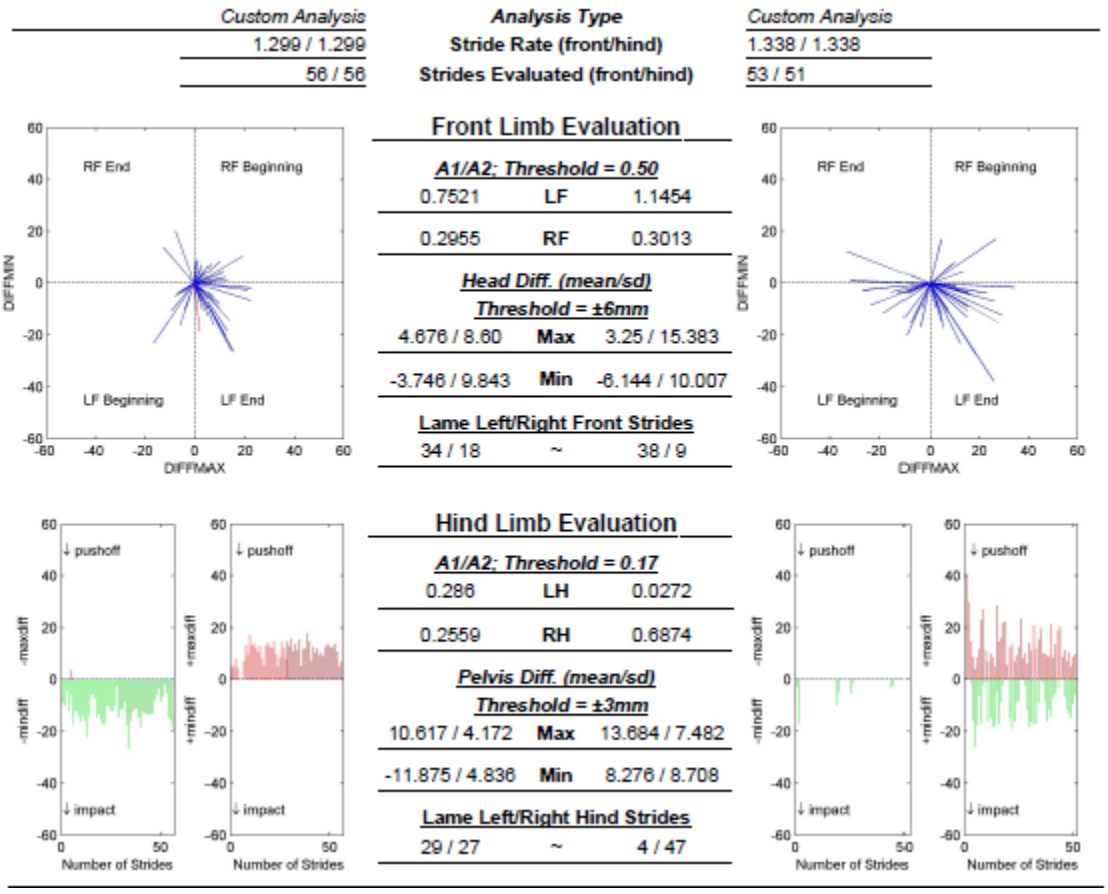
It should first be mentioned that, in this trial, only 19 strides were evaluated. In order to acquire more reliable results, trials should be collected such that at least 25 strides are analyzed. Depending on the activity, not every stride collected will be analyzed. Thus, it is best to collect 25 to 35 strides per trial.

Forelimb evaluation:
There is an accumulation of rays in the "LF End" quadrant. This is indicative of LF end-of-stance or push off type lameness. End-of-stance forelimb lameness is uncommon. ***Strike 1*** for LF.
LF A1/A2 (0.6) is slightly elevated above the threshold of 0.5. ***Strike 2*** for the LF.
Mean Max Diff Head (9.9 mm) is slightly elevated above the threshold of +/- 6 mm, ***Strike 3*** for the LF, and the standard deviation (8.2 mm) is slightly less than the mean, ***Strike 4*** for the LF.
Although they are weak strikes, just outside normal range, this horse has 4 strikes against the LF.

Hind limb evaluation:
There is a preponderance of red rays pointing up on the right, indicating RH push off type lameness. ***Strike 1*** for the RH.
RH A1/A2 ratio (0.35) is double normal threshold of 0.17. ***Strike 2*** for the RH.
Mean Max Diff Pelvis (10.8 mm) is elevated above the threshold of +/- 3 mm, ***Strike 3*** for the RH, and the standard deviation (2.5 mm) is less than the corresponding mean, ***Strike 4*** for the RH.
This horse has 4 strikes against the LF and RH; however, the strikes are stronger (relatively higher above normal threshold) against the RH than LF. The RH lameness is more convincing than the LF and therefore the most likely to be predominant.

Note: *For hind limb evaluations, Max Diff Pelvis values reflect the end-of-stance or push off phase of stride and the Min Diff Pelvis values reflect the beginning-of-stance or impact phase of the stride. By convention LH lameness results in negative (< 0) Max Diff and Min Diff values and RH lameness results in positive (>0) Max Diff and Min Diff values. For example, a RH push off type lameness would have Pelvic Max Diff values that are above threshold |+/- 3 mm| and positive (> 0).*

The lunging data for this horse is shown below with lunging to the left on the left and lunging to the right on the right.



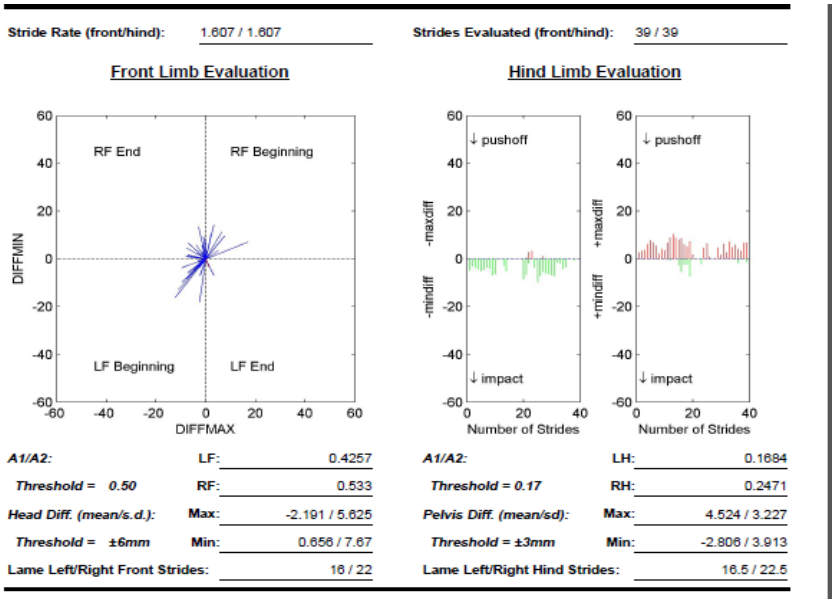
Remember, users should not simply compare calculated lameness values (A1/A2 ratio, Head and Pelvis Max and Min Diffs) to the normal threshold values listed on the report. Users should instead compare calculated lameness values between lunging to the left and lunging to the right.

Forelimb evaluation:
There is no accumulation of rays in any direction or quadrant when the horse is lunging to the left. Most rays are pointing down toward the LF when the horse is lunging to the right, so there is slight evidence

of LF lameness when the horse is lunging to the right. However, there are no consistent elevations of mean Max Diff Head or Min Diff Head in one direction compared to the other and the standard deviations of Max Diff Head and Min Diff Head are greater than their respective means. There is no strong evidence that this horse has forelimb lameness during the lunge.

Hind limb evaluation:
The pattern seen while the horse is lunging to the left, red rays up on the right hind (positive mean Max Diff Pelvis) and green rays down on the left hind (negative mean Min Diff Pelvis) are often seen in sound horses, i.e. this is an expected pattern in normal horses. An “equal-in-amplitude”, but “opposite-in-direction”, expected pattern for this horse while lunging to the right would be red rays up on the left hind (negative mean Max Diff Pelvis) and green rays down on the right hind (positive mean Min Diff Pelvis). However, when lunging to the right both Max Diff Pelvis and Min Diff Pelvis are positive. The positive Max Diff when lunging to the right is unexpected. The horse is displaying RH push off lameness when lunging to the right. This is consistent to that seen while the horse was trotting in a straight line.

An example of a horse with notable pelvic asymmetry.



Horses with asymmetric vertical tuber sacrale heights may register asymmetries in vertical pelvic movement. This may be artifactual due to the physical asymmetry of the horse, or it may be due to lameness. Asymmetric vertical tuber sacrale height is an important physical exam finding that should be noticed and noted when instrumenting the horse. It should be taken into account when evaluating the results. The side with the higher tuber sacrale may register as an impact asymmetry and the side with the lower tuber sacrale may indicate push off asymmetry. As an example, in the case below, this horse exhibits asymmetric pelvis, with the left tuber sacrale higher than the right. No other abnormal findings were noted when evaluating the horse in motion.