

**Analysis of coffin and shoulder joint
lameness with an inertial sensor-based
system:
impact versus pushoff**

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The undersigned, appointed by the Dean of the Graduate School, have examined the thesis entitled

**Analysis of coffin and shoulder joint lameness with an inertial sensor-based system:
(impact versus pushoff)**

Presented by Adam Al Abidi,

A candidate for the degree of master of veterinary medicine and surgery, and hereby certify that, in their opinion, it is worthy of acceptance

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Dedication

First of all I thank god for everything he gave me. I dedicate this to my father and mother for their support where ever I was. I thank my lovely wife for encouraging me and standing next to me through the good times and hard times, she was always there for me.

Acknowledgments

I would like to thank all of my committee members for believing in me and for their help, support and understanding. Thanks to Dr. David Wilson and Dr. Frank Pai for their help and I thank this great person my advisor Dr. Kevin Keegan for all of his help and support all the way through this project. I also thank Dr. Marco Lopes for standing beside me and helping me in this study. And I thank every person in the Equine teaching hospital for treating me nice and with respect. And I thank the University of Columbia Missouri for giving me this great opportunity.

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Analysis of coffin and shoulder joint lameness with an inertial sensor-based system: impact versus pushoff

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ABSTRACT

Reason for performing the study: An inertial sensor-based system (Lameness Locator® [LL]) can help veterinarians detect mild lameness. It would be beneficial if this tool could also be used to distinguish lamenesses produced by lesions in different structures.

Hypotheses: Coffin arthritis predominantly causes impact lameness while shoulder arthritis predominantly causes pushoff lameness.

Objective: To investigate if shoulder arthritis causes pushoff lameness and coffin arthritis causes impact lameness and if these lamenesses can be differentiated by comparing the phase angle of the resultant ray calculated by the LL.

Methods: Using a crossover design, coffin and shoulder arthritis were alternately induced in 12 horses with intra-articular injection of IL-1 β . Immediately before injection and every 6-12 h thereafter, the horses were evaluated with the LL. This evaluation was performed while the horses were trotted in hand in a straight line on a hard surface for about 120m. The phase angle (= arctangent [MINDIFF mean / MAXDIFF mean]) of each type of lameness (coffin or shoulder arthritis) were compared with the Wilcoxon signed-rank test using data from the last time point before lameness was no longer detectable.

Results: No difference could be detected ($p=0.625$) between the phase angle when coffin (median, 81°; range, 58-123°) and shoulder arthritis (median, 86°; range, 59-104°) were compared.

Conclusion: Coffin arthritis and shoulder arthritis did not consistently cause impact lameness and pushoff lameness, respectively.

INTRODUCTION

Lameness is a very common problem affecting horses. It is important due to its economic impact as well as limiting the quality of life of the athletic horse. The economic loss due to lameness in the horse is estimated to be approximately 600 million to 1 billion dollars annually to the horse-owning public (1 and 19). Lameness is defined as "incapable of normal locomotion, deviation from the normal gait" (2). It is important to emphasize that it is not related to limbs only. It can also result from pathologic conditions of the back or neck of the horse (6). It can occur from conditions that effect tendons, muscles, bones, ligaments and hooves of the horse. It can be caused by many factors including trauma, which is one of the most common causes. Sepsis, especially involving joints, is another common cause of lameness along with neurologic abnormality and developmental diseases, such as osteochondrosis and degenerative joint disease.

Lameness evaluation:

The traditional and most accepted method of detecting lameness in horses and judging its severity is subjective evaluation. This includes palpation of the limbs and torso of the horse and then observing the movement of the horse, generally at the walk and trot. The lameness may then be graded for severity by using one of a few published grading systems such as the 0-5 scale known as the AAEP grading system, which is used most commonly in the United States. These systems, however do not actually define what it is that one should observe. There are many different parameters noted in most popular equine lameness textbooks. These include stride length and timing of hoof falls, trajectories of hoof flight, joint angle excursions and head and torso movement. For forelimb lameness, the "head bob" is considered by many to be the most sensitive and easiest to appreciate. Exact definitions of the "head bob" is, are hard to come by, but most agree that the head "bobs" or moves up and down more quickly or over a greater range of motion when the lame limb is weight bearing. Whether it is the "bob" up or the "bob" down which is most important as the indicator of lameness is frequently just a matter of opinion. There is evidence that the vertical movement of the head has a direct relationship with measured vertical ground reactions (3, 4, 7, 8 and 9). Decreased vertical ground reaction force during weight

bearing of the lame limb is a definitive measurement of lameness. The simplest explanation of the "head bob", popularized in equine textbooks, is that the head "bobs down" on the non-lame forelimb and "bobs up" on the lame forelimb. Close inspection of vertical head movement with slow motion video or with objective kinematic measurements indicates that this is really true only when forelimb lameness is quite severe. In actuality, the head moves down and then up, of course to different degrees, during each forelimb stance, lame and sound. Therefore, more refined definitions, necessary to explain head movement in horses with more mild to moderate lameness, requires more exacting observations. Some veterinarians indicate they observe the rise of the head to determine which limb is lame. Others observe the head moving down to determine which limb is lame. The first method, however, is a little problematic, since many veterinarians indicate that the head rises to its highest position right before impact of the lame forelimb. Others indicate that the horse thrusts its head upward during pushoff, or the second half of stance. In other words, some think the head rises after pushoff of the good limb and some think the head rises after pushoff of the lame limb. Obviously, this is a contradiction. The second method is more straight forward and most would agree that the head moves down more during weight bearing of the good limb compared to the lame limb. This is frequently quoted as

a maxim in equine lameness detection and it is known as “down on sound”. Nevertheless, there are some equine veterinarians that are “upward moving” head observers, and some that are “downwardly moving” head observers.

Certainly, this lack of a “standard” method of observing head movement is one of the factors involved that explains the high degree of disagreement between expert observers for detecting lameness in horses (15, 20 and 18). This is especially true in lameness cases of mild severity because of the limited temporal resolution of the human eye. Another factor limiting subjective evaluation is bias. Evaluators blinded to whether the horse is blocked or not will grade lameness severity lower if they thought the horse was blocked (5).

To prevent bias and address the limitations of subjective evaluation, objective evaluation methods are being developed. Objective methods of lameness evaluation, at least theoretically, should be more repeatable, accurate and sensitive.

There are two different general methods for objective evaluation of lameness in horses; kinetics and kinematics. Kinetics measures the ground reaction force on the limbs. Kinematics, by contrast, measures the movement of the body. Kinetics can rightly be considered to be the most direct method, but it is least intuitive. Kinematics, on the other

hand, is really an indirect method, since movement of the body is what results from altered ground reaction forces. However, it is more intuitive and, therefore, since it is the movement of the body that veterinarians actually observe, it is more understandable to practitioners than, kinetic methods.

The stationary force plate is the most common kinetic method used. It is precise and accurate. Some consider it the gold standard of lameness detection and measurement in horses. It is capable of measuring all 3 orthogonal ground reaction forces; vertical, horizontal and transverse. However, there are some disadvantages to this method. Data from only one strike of one limb on the force plate can be obtained with each collection. In order to obtain sufficient data, multiple collections are required due to stride-to-stride variability in lameness. Only about 1 in 4 attempts result in a successful collection of a good limb strike, even under controlled conditions. The ground reaction forces are known to be highly dependent upon speed of movement, thus speed of movement of the horse must be tightly controlled. Successful strikes on the force plate take practice (for both the human evaluator and the horse) and skill.

To obtain a large data set, many trials are needed. In each trial only one limb can be evaluated at a time. Using a stationary force plate to measure lameness in the horse is very time consuming. The stationary

force plate also needs to be well maintained and it is location specific. It needs to be positioned such that the surface is level with the surrounding ground to allow for even footing before, during and after stepping on the force plate. In general it is a highly sensitive piece of equipment that takes skill, time and knowledge to use and maintain (21, 29 and 30).

An alternative to the stationary force plate is the pressure sensitive mat which consists of a series of piezo sensors embedded in a mobile surface. The pressure sensitive mat has a small advantage in one aspect over the stationary force plate. It can evaluate up to 2 limb strikes, simultaneously in a single trial. However, the pressure sensitive mat is more delicate than the stationary force plate and only vertical ground reaction forces are measured. Measurement of ground reaction force is not as accurate as the stationary force plate. One big advantage of the pressure sensitive mat over the stationary force plate is its ability to sample distribution of forces over the contact area of hoof impact. Thus, it is most beneficial to evaluating trimming and shoeing practices. Because of its delicate nature, it is usually only suitable to have the horse walk over the mat. Therefore, it is not very useful as an objective lameness evaluation tool. It is also difficult to maintain (21).

Some laboratories around the world have developed force-measuring horse shoes. Use of such shoes mitigates the limitation of not being able to collect multiple strides in a single collection attempt. However, they too are delicate and require a protective construction to stand up to the impact forces seen in walking and trotting horses. This protective construction necessitates that the end product is quite large and heavy, which significantly affects the normal movement, and therefore lameness of the horse (11, 12, 13, 14, and 16).

The epitomy of kinetic measurements of lameness in horses is manifest in the force measuring equine treadmill. There is only one existing in the world, at the University of Zurich in Switzerland. It is a treadmill, but with over 20 piezoelectric sensors embedded in the treadmill belt. It can measure only vertical ground reaction force, but it can do so over many contiguous strides and on all 4 limbs at the same time. Lameness on the treadmill may not reflect the true nature of the clinical problem, as locomotion on the treadmill differs from locomotion over the ground. Because of the expertise and expense required to operate the force measuring treadmill, its use and development for routine lameness evaluation worldwide is unlikely (15).

Kinematic methods:

Kinematic methods usually rely on detecting asymmetry of movement between the left and right side of the horse and most methods rely on line-of-site detection. Obstructions of the visual field will always limit the usefulness of kinematic methods.

The easiest and least expensive method of kinematic measurement is to simply film the horse moving with a camera and then review the archived movie, either in regular speed repeatedly, or in slow motion, which effectively magnifies the temporal resolution. Some objective measurement tool needs to be used in the evaluation, for example, projecting the film on a surface and measuring movement with a ruler, or using some computer screen digitization of distance otherwise the limitations of subjective evaluation are still present.

A more sophisticated kinematic technique is to use high speed cameras, with trackable markers placed on the body and computer-assisted measurements of marker trajectories. There are a few commercially available systems such as the Motion Analysis System and the Vicon Motion Analysis System. More than 1 camera is required to get true 3D measurement. Accuracy is dependent upon the ratio of the size of the movement to be detected to the size of the field-of-view of the camera. To detect equine lameness with sufficient

precision and accuracy, the size of the field-of-view should approximate the size of the horse. Therefore, in order to acquire contiguous strides, which handles stride-by-stride variability of lameness, the horse movement is usually captured when the horse is moving on a high speed treadmill (33, 33 and 34). High speed cameras can be as expensive as the treadmill. Horses also need to be trained to trot on the treadmill, and the horse's movement on the treadmill, as mentioned earlier, is not the same as what is observed over ground (9). When the horse is trotting on the treadmill the horse is not really pushing off, instead the horse is just picking up the limbs from off the belt. In addition, impact may be greater because the belt is moving in the opposite direction of limb at the time of impact. Sometimes this can hide the lameness or it might increase the lameness depending on the type of lameness. The primary advantage of filming the horse is that objective measurements can be made and much data can be analyzed quickly.

In attempts to develop an objective method of lameness evaluation in horses that minimizes most of the previously-mentioned limitations, several laboratories around the world have been developing body-mounted inertial sensor systems. In one sense these inertial sensor systems can be considered kinetic systems because they measure torso acceleration which is directly related to ground reaction forces

($F=ma$) (38). However, since they measure movement they are usually described as a kinematic technique. Torso movement is considered to be the most sensitive indicator of lameness in horses. Inertial sensors, like the markers in traditional kinematic systems, are attached to the body sites of the horse that have been previously described as indicative of lameness. The major advantages over camera-based kinematic systems are that they do not depend on maintaining line-of-site and no expensive cameras are needed. Also they can wirelessly transmit data over fairly large distances to be stored in a computer. There are a few commercially- available systems including Equimetrix® from Centaure Metrix, EquuSense 1.0 from EquuSys and Lameness Locator® from Equinosis. These systems vary greatly in their cost, complexity and applicability.

Lameness Locator® is a system that was invented and developed by veterinarians and engineers at the University of Missouri Columbia in collaboration with the Hiroshima Institute of Technology in Japan. It consists of three inertial sensors (2 accelerometers and 1 gyroscope). They are attached to the body of the horse; one accelerometer is attached to the head of the horse (halter), a second accelerometer is attached to the pelvis using tape or a pelvic clip, and one gyroscope is attached to the right forelimb at the pastern region using a special

wrap. Data is transmitted from the sensors to a tablet computer in real time and the data is received through a USB connection via Bluetooth.

Lameness Locator® measures the vertical torso (head for forelimb lameness and pelvis for hind limb lameness) acceleration and detects the asymmetry between the right and left sides of the horse. Vertical torso acceleration is converted to position using an error-correcting double integration. The vertical position signal is then decomposed into harmonics and a random moving window component.

The harmonics are summed to get overall vertical head (for forelimb lameness) and pelvis (for hind limb lameness) movement. One harmonic at 1x the stride rate represents the lameness component of vertical movement. The harmonic at 2x the stride rate indicates what could be considered as the normal vertical movement of the head or pelvis. The amplitude of lameness is estimated by measuring the difference in maximum and minimum head (MAXDIFFHEAD, MINDIFFHESD) and pelvis (MAXDIFFPELVIS, MINDIFFPELVIS) heights between the left and right strides determined from the sum of the harmonics. Left and right strides are determined from an event marker contributed by the gyroscope placed on the right forelimb. It is also thought the shape of the sum of the harmonics, which is indicated by the sign (+/-) and amplitude of the MAXDIFF and MINDIFF, represents the timing of lameness. In other words, whether the lameness is

occurring as a change in the downward acceleration of the torso (impact lameness) or the upward acceleration of the torso (pushoff lameness). If this were true then this information would be of great use to veterinarians trying to localize lameness within the limb.

Lameness Locator®, for measurement of forelimb lameness, measures and reports the MAXDIFFHEAD and MINDIFFHEAD. These are measured for every stride and the mean and standard deviation over all strides are reported.

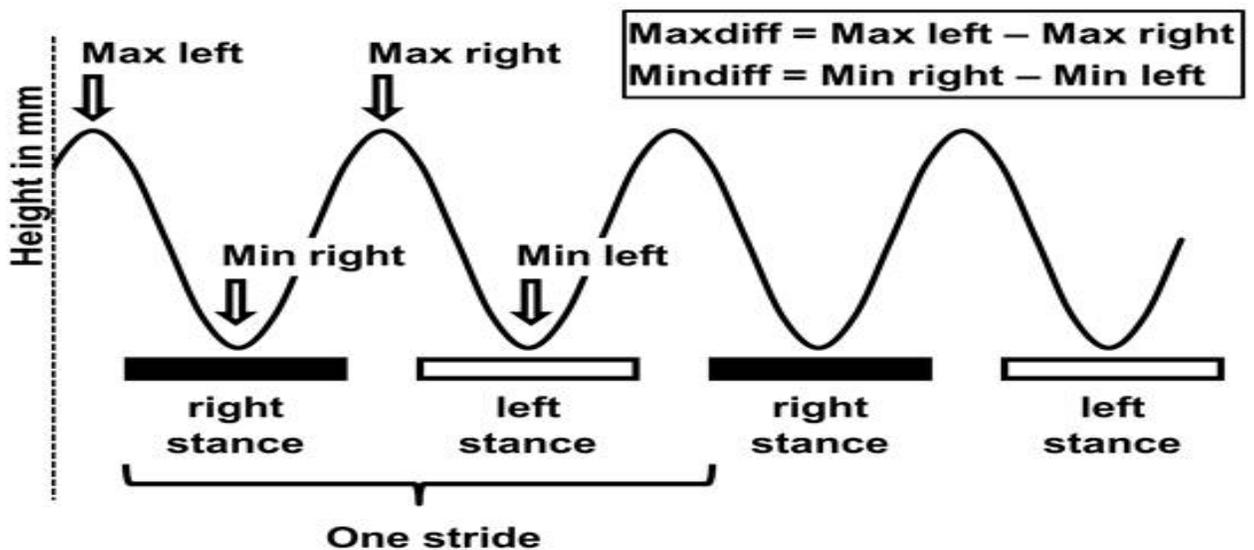


Figure 1 - Graphic representation of the vertical head movement in a sound horse moving at the trot. The values of MAXDIFF and MINDIFF are close to zero. Modified from reference 39.

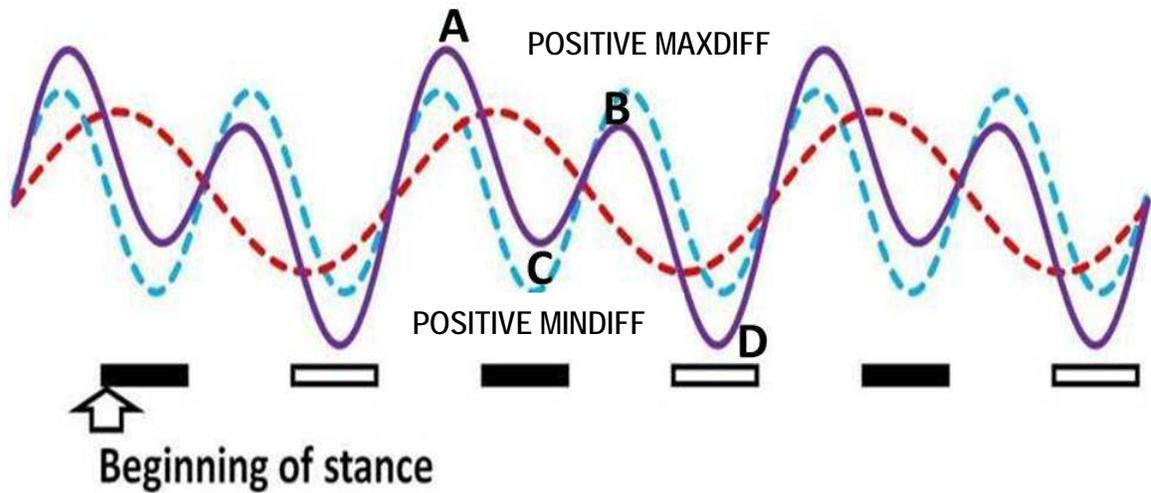


Figure 2 – Graphic representation of the vertical head movement of a horse with right front limb impact lameness (purple curve). The blue curve represents the head movement observed in a sound horse. The red curve represents the lameness component. The purple curve is the summation of the blue and red curves. MAXDIFF (= peak before the stance of the right front limb [A] minus peak after the stance of the right front limb [B]) and MINDIFF (= lowest point during the stance of the right front limb [C] minus lowest point during the stance of the left front limb [D]) are positive. Modified from reference 39.

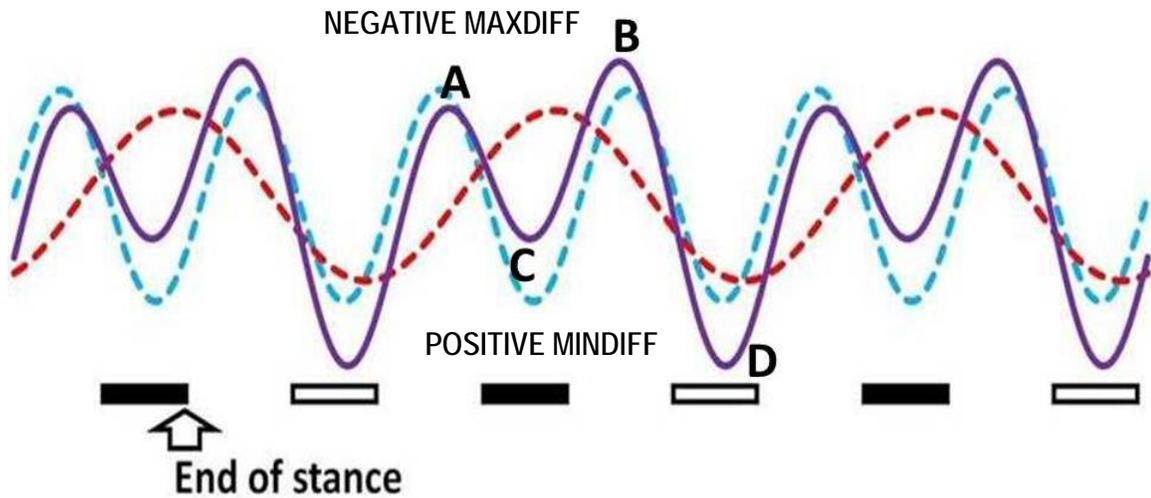


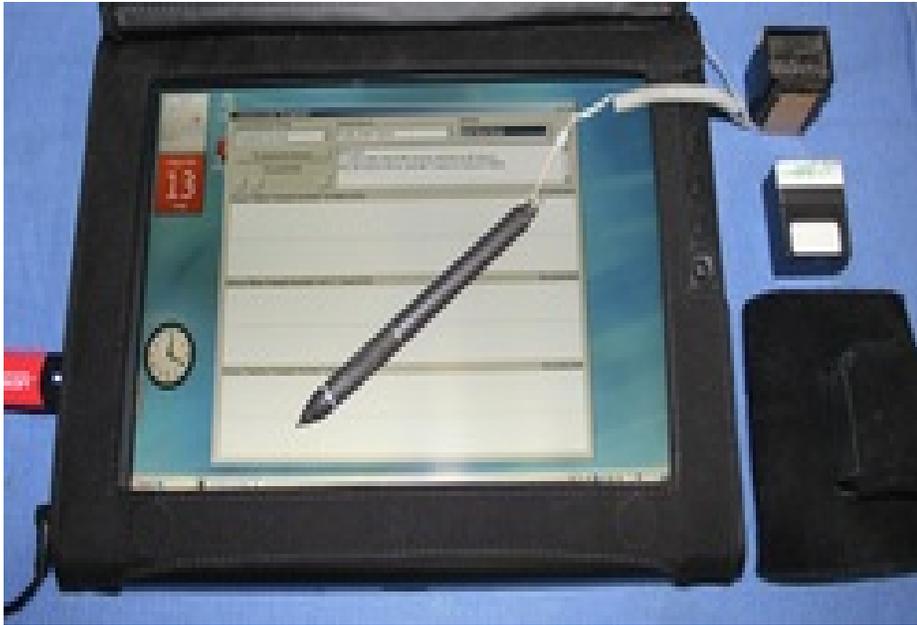
Figure 3 – Graphic representation of the vertical head movement of a horse with right front limb pushoff lameness (purple curve). The blue curve represents the head movement observed in a sound horse. The red curve represents the lameness component. The purple curve is the summation of the blue and red curves. MAXDIFF (= peak before the stance of the right front limb [A] minus peak after the stance of the right front limb [B]) is negative and MINDIFF (= lowest point during the stance of the right front limb [C] minus lowest point during the stance of the left front limb [D]) is positive. Modified from reference 39.

Sensor Placement:



Lameness Locator® by Equinosis™

Figure 4- illustration for the three sensors placed in their location on the horse's body



Lameness Locator® by Equinosis

Figure 5- illustration for the portable computer of the Lameness Locator®, and the USB is attached to the portable computer to receive the transmitted data from the sensors

Detecting forelimb lameness using Lameness Locator®:

The results are represented in a graphical display. They appear as a ray diagram on the computer monitor. Each ray represents a stride and the length of the ray represents the amplitude of the asymmetric head motion of that stride. The accumulation of rays in one of the four quadrants indicates the side and timing of the lameness.

The MAXDIFF and MINDIFF are also calculated for each stride. The sign (+/-) for the MAXDIFF and MINDIFF determines the side and timing of the lameness, with a threshold of +/- 6 mm. From these variables, the phase angle (θ) is calculated. $\theta = \arctangent = (MINDIFF/MAXDIFF (180/\pi))$ to be represented in degrees. Impact lameness theoretically results in θ values $> 90^\circ$. Pushoff lameness will theoretically result in θ values $< 90^\circ$.

Inducing lameness:

There are multiple methods to induce lameness. In one study, lameness was induced by administration of oligofructose dissolved in tap water administered to the horse via nasogastric tube in order to create laminitis. (25).

In another study, lameness was achieved by iatrogenic hemarthrosis by injecting autogenous blood in the metacarpophalangeal joint causing a temporary reversible lameness (24). Lameness was also

induced by using shoes that had a 3/8 inch nut welded to the inside of each branch of the shoe dorsal to the apex of the frog. Lameness was caused by inserting screws through the nuts and tightening the screw until it exerted pressure on the sole of the toe (23). Another method of inducing lameness was by creating an osteochondral fragment in the knee of the horse with the guidance of arthroscopy. However, this method caused irreversible lameness (22).

Interleukin-1

Cytokines are soluble polypeptides that are produced from one cell activity affecting another cell type. Studies of cytokines suggest that IL-1 and TNF α modulate the synthesis of metalloproteinase by both synovial cells and chondrocytes. Therefore, they are important mediators in joint disease (35, 36 and 37).

Interleukin- 1 is currently known to play a central role in joint disease. It is also considered a central mediator of cartilage loss in OA in many species. It is well documented that the increase and presences of interleukin -1 in the joint will lead to the activation of inflammatory processes in that joint. It also contributes to the pathogenesis of arthritis by increasing the proliferation of mesenchymal cells and by enhancing the expression of other inflammatory mediators. There are

many sources that secrete interleukin- 1 in the tissue. The main sources are macrophages and monocytes (28).

Recombinant Equine IL-1 β was used in this study to induce lameness. It is composed of two pleiotropic cytokines, IL-1 α and IL-1 β . These two cytokines are a product of distinct genes. The source of recombinant equine IL-1 β is from the DNA sequence encoding the mature equine IL-1 β . It has a molecular mass of 17 K Da and consists of 153 amino acid residues (Recombinant Equine IL-1 β , R&D Systems, Inc.).

The aim of this study was to observe if there was a significant difference in the phase angle between the type of lameness induced in the coffin joint and the type of lameness induced in the shoulder joint.

MATERIALS AND METHODS

12 horses owned by the (Veterinary Teaching Hospital) were used in this study. All horses were females with ages ranging from 3-22 years and weight ranging from 318-573 kg. There were 10 American Quarter horses, one Thoroughbred and one pony.

Lameness was evaluated by evaluating the variables (mean and standard deviation) for MAXDIFF and MINDIFF, generated by the Lameness Locator®. From the value of both MAXDIFF and MINDIFF, the phase angle is calculated and reported in units of degrees.

Study design:

A randomized cross-over design study was conducted. Horses were evaluated before injection using the Lameness Locator®. Two separate trials were performed. Each trial consisted of trotting each horse in a straight line on a concrete surface for a distance about of 120 meters. This resulted in the collection of at least 25 strides per trial. Horses were included in the study if no severe lameness was detected in the baseline evaluation. The limb to be injected was randomly selected unless there was any sign of mild front limb lameness. If mild front limb lameness was detected in the baseline evaluation, the non-lame

limb was selected for injection. The horses were then sedated with intravenous detomidine and butorphanol. Then they were injected with either 300 ng IL-1 β in the coffin joint or 500 ng of IL-1 β in the shoulder joint, depending on the randomization. After injection, horses were first evaluated with the Lameness Locator[®] at 12 hours after the injection by trotting them in a straight line on a concrete surface. Two separate trials were done. Evaluation was continued every 6-12 hours until very mild lameness was detected. After the lameness resolved, horses were rested for 30 days.

After 30 days the horses were evaluated again using the Lameness Locator[®]. They were trotted in a straight line on a concrete surface for a distance of about 120 meters. Two separate trials were done. If no lameness was detected they were injected in the opposite joint from the previous joint injection. They were evaluated after 12 hours from the injection and the evaluation was continued every 6-12 hours until a very mild lameness was detected. If the horse was not lame after 12 hours from the injection, the injection was repeated 24 hours after the initial injection.

Interleukin-1 preparation:

IL-1 dilution:

One ml of phosphate buffered saline (PBS) was added to a vial which contains 10 µg of rEq IL-1β lyophilized and then passed through a millipore filter. One ml was drawn into a syringe and placed back in the vial to mix the PBS and the rEq IL-1. Nine ml of PBS was drawn and injected into a 10 ml sterile vial through a millipore filter. Then 1 ml of 10 µg/ml solution was added to the 10 ml vial, which already contained 9 ml PBS to get a 1 µg/ml solution.

Then 1 ml of 1 µg/ml solution was removed and replaced in a 10 ml sterile vial. This was repeated ten times in order to obtain ten of 10 ml sterile vials. Each vial contained 1 ml of 1 µg/ml solution. The remaining 9 vials were kept frozen.

Nine ml PBS were added through a millipore filter to the tenth vial to get a 0.1 µg/ml (100 ng/ml) solution. The frozen vials were stored under sterile condition at 2°- 8°C for one month or at -20°C to 70°C for three months without losing its activity.

Injection technique:

Horses were sedated by administering 3-8 mg of detomidine and 5 mg of butorphanol intravenously. The area of injection was then clipped and prepared aseptically with betadine and alcohol. Arthrocentesis was performed by injecting IL-1 β in the coffin joint or the shoulder joint. Arthrocentesis of the coffin joint was achieved using the dorsal approach by injecting 300 ng of rEq IL-1 β into the joint using a 1-1.5 inch, 18-20 gauge needle. Arthrocentesis of the shoulder joint was achieved using the craniolateral approach by injecting 500ng of rEq IL-1 β in the notch between the cranial and caudal prominences of the greater tubercle of the humerus using a 3.5, 18 gauge spinal needle. Joint fluid was aspirated to determine successful joint entry.

Data analysis:

Data was generated by the Lameness Locator® software. Evaluation of the lameness was performed when the lameness decreased to a mild lameness after lameness peaked after injection. The selection was made based on the mean and standard deviation of the MAXDIFF and MINDIFF. The values were collected for both coffin and shoulder joint trials and matched for equivalent severity for each horse.

Phase angle was calculated using the formula:

$[r = \arctangent * (\text{MINDIFF mean} / \text{MAXDIFF mean})]$.

From this formula the phase angle was calculated in radians. To convert it to degrees the formula $[\text{degrees} = \text{radians} * 180 / \pi]$ was used.

Statistical analysis:

Due to the small number of samples no assumption was made for normal distribution. Therefore, we performed a non-parametric test for the statistical analysis. Since this study was a paired study, a Wilcoxon signed rank test was used. Significant was set at a $P < 0.05$.

RESULTS

The phase angle was calculated for both coffin and shoulder joints. The phase angle for the coffin joint had a median of 81° with a range 58° - 123° . The phase angle for the shoulder had a median of 86° with a range 59° - 104° , (p value =0.625). Based on these results, there is no significant difference between the phase angle of the coffin joint and the shoulder joint.

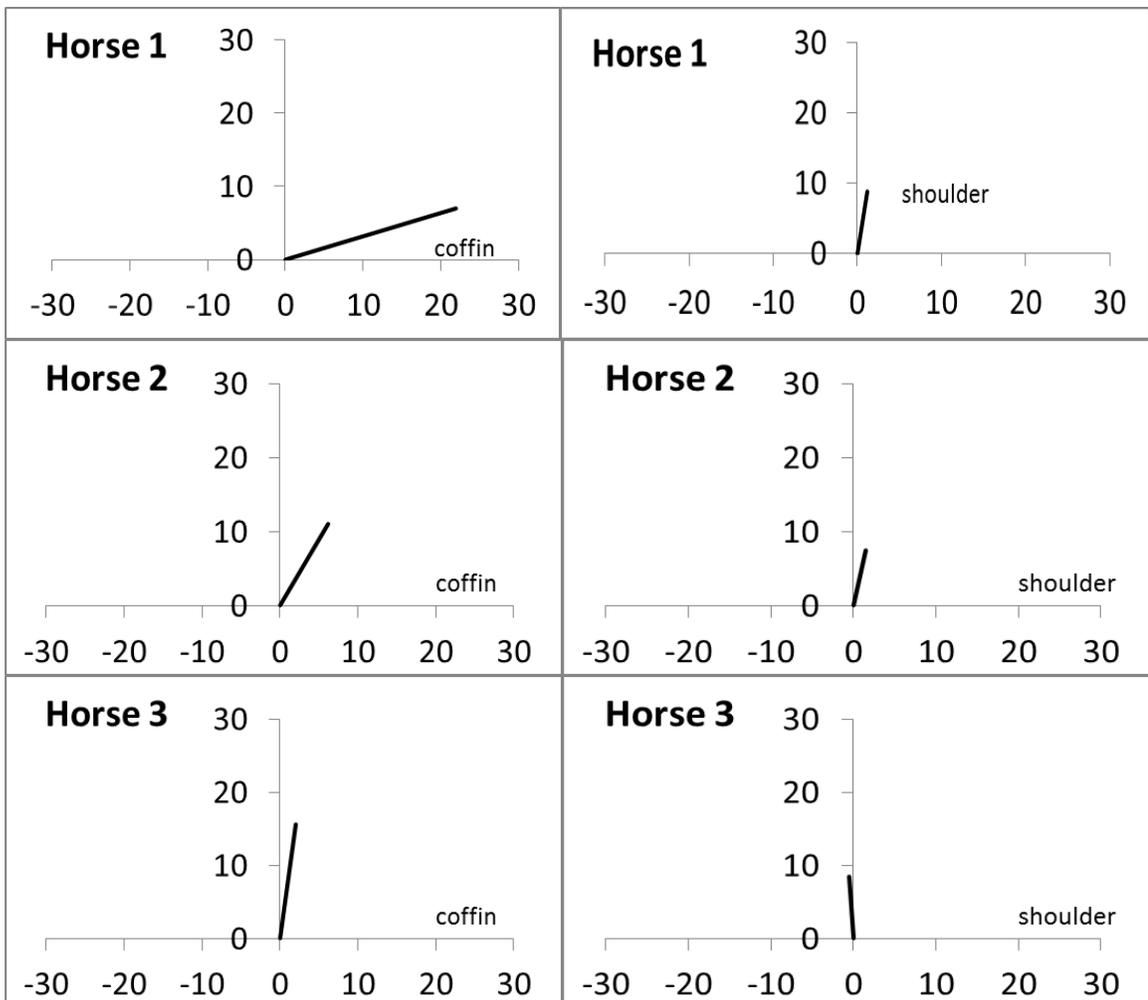
Out of 12 horses, two were eliminated from the study. One horse was eliminated due to high variability. The horse misbehaved significantly in one of the paired trials. A second horse was eliminated after the first injection when it developed lameness in the opposite forelimb. This lameness did not resolve, so the second injection was not performed.

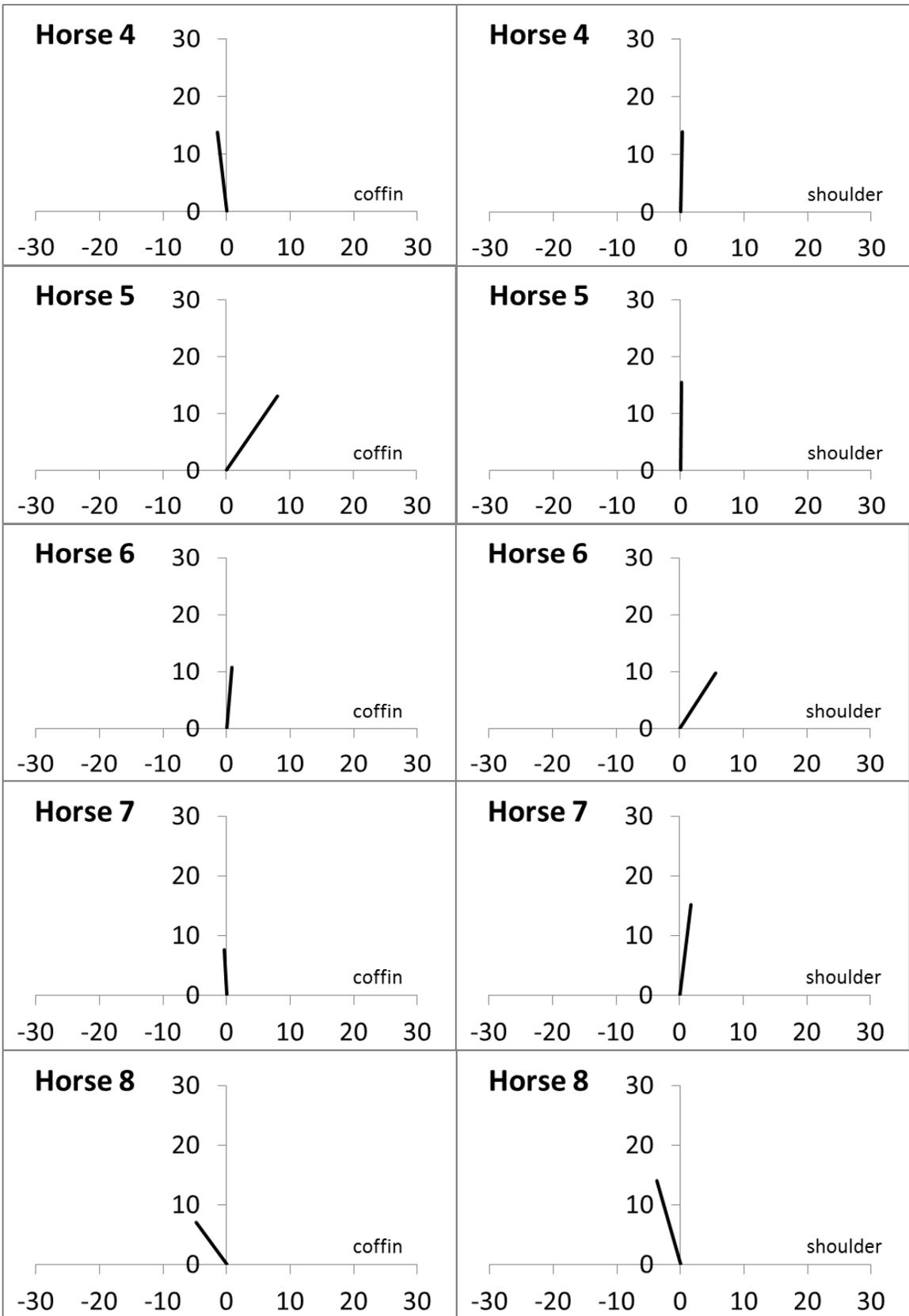
From the 10 horses, 4 horses had an impact lameness ($\theta < 90^{\circ}$) for both coffin and shoulder joints, 4 horses had a pushoff lameness ($\theta > 90^{\circ}$) for the coffin joint and an impact lameness for the shoulder joint, one horse had a pushoff lameness for both coffin and shoulder joints, and one horse had an impact lameness for the coffin joint and a pushoff for the shoulder joint.

The peak of lameness following injection of IL- 1β for the coffin joint had a median of 9 hours and a range 6 -14 hours. The peak of

lameness for the shoulder joint had a median of 12 hours with a range 6 - 37 hours.

One horse had mild fever 12 hours after the injection which can be due to the effect of IL-1 β . Otherwise all horses returned to the pasture in a healthy condition and with no lameness related to the study.





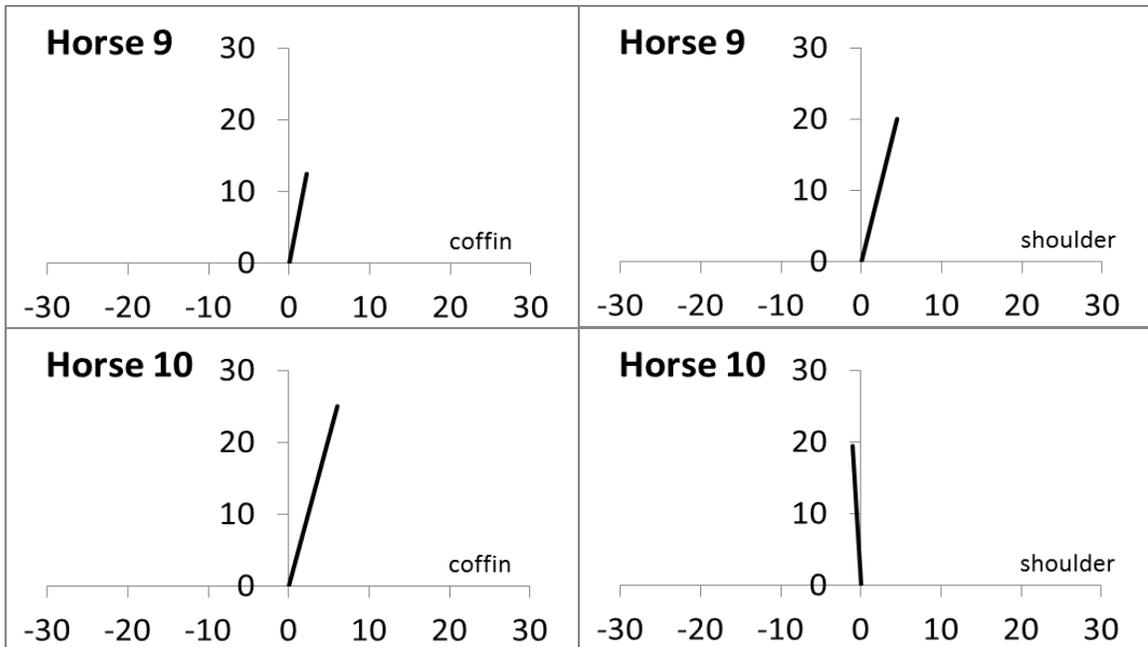


Figure 6 – Graphic representation of the phase angle ($=180 \cdot \arctangent [MINDIFF/MAXDIFF] / \pi$) from ten horses treated with intra-articular IL-1 twice (coffin and shoulder joints). Washout period between injections was at least 30 days. Phase angle below 90° indicates impact lameness. Phase angle above 90° indicates pushoff lameness.

DISCUSSION

There was no significant difference between the phase angle for the coffin joint and the shoulder joint. This can be due to the small number of samples. There was no significant difference between push-off lameness versus impact lameness in relation to whether it was coffin or shoulder joint.

In this study intra-articular rEq IL-1 β was chosen to create lameness. This method was chosen because reversible mild lameness could be created without any long terms complications affecting the horses. However, some horses did not get lame after the initial injection; the injection was repeated 24 hours after the first injection to induce lameness suitable for evaluation.

Limitations of the study:

The main limitation in this study was the sample number. A small number of samples can statistically affect the power of the study. Time of the evaluation was also a limitation. Horses were evaluated every six hours for lameness; however, better results could possibly have been obtained if the evaluation was every hour. On the other hand

evaluating the horses every hour could stress them and may have aggravated the lameness.

One explanation for the lack of significant results in this study is that IL-1 β might have migrated from the coffin joint into the navicular bursa, which may cause the lameness to change, and for the shoulder joint IL-1 β may have migrated to the bicipital bursa causing the lameness to change.

Another explanation is the lameness model was not suitable. We created lameness in the bony column at the proximal and distal joints, since both joints are diarthrodial; they might have the same reaction to lameness. However, better results may be present if a different lameness model was used. If we created bony column lameness in one of the joints (arthritis) and lameness in the tendon (tendonitis), this might show different results.

In conclusion we found that there is no significant difference between types of lameness induced with rEq IL-1 β , whether the lameness was impact or pushoff for the coffin joint and shoulder joint.

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