Pelvic Movement Pattern in Horses With Hindlimb and Forelimb Lameness

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The vertical pelvic movement patterns in horses with hindlimb lameness may contain information useful for determining the instant of peak pain within the stride cycle. This information may be helpful to the practitioner in isolating lameness within the affected limb. Author’s address: E. Paige Laurie Endowed Program in Equine Lameness, College of Veterinary Medicine, University of Missouri, Columbia, MO 65211; e-mail: keegank@missouri.edu. © 2005 AAEP.

1. Introduction

Most equine practitioners look at how the horse’s pelvis moves during a trot to help them detect hindlimb lameness. Hip hike, hip drop, and gluteal rise are terms frequently used to describe hindlimb lameness in the horse. Objective and precise measurements of pelvic movement in lame horses have been made in experimental studies. The observations from these studies explain much about pelvic movement in lameness, and close evaluation of this information may tell us something about the specific lameness being evaluated. This paper will first try to document what is written in the most popular equine lameness textbooks about how to use pelvic movement to detect hindlimb lameness and then compare these descriptions to what has been determined by controlled objective analysis of the pelvic-movement patterns in sound and lame horses. In the later part of this paper, I will comment on pelvic movement patterns in horses with primary forelimb lameness; finally, I will introduce a hypothesis that the specific pelvic-movement patterns observed help the evaluator determine the type of lameness (i.e., when the pain is occurring during the stride).

2. What the Textbooks Say

"In the painful situation, most horses tend to get off the hindlimb more quickly and the gluteal muscle contraction is shortened which leads to a shortened duration of gluteal rise . . . a depressed gluteal rise and a decreased duration is usually seen in horses that are in pain during the swinging phase of the stride . . . a symmetric gluteal rise equaling that of the opposite hip but of decreased duration . . . is usually seen in cases with subtle hindlimb lameness . . . an increased gluteal rise ('hip hike') in which the affected limb is brought higher than the normal limb but the duration of gluteal rise is shortened . . . is usually seen in horses that are in pain during the support phase of the stride."1

"An important principle in the recognition of hindlimb lameness is the concept of pelvic height or asymmetrical movement of the pelvis . . . this has been termed pelvic hike . . . the entire pelvis, not just the lame side of the pelvis, appears to undergo elevation . . . pelvic hike is the vertical elevation of the pelvis when the lame limb is weight bearing . . . the pelvis "hikes" upward when the lame limb
hits the ground and moves downward when the sound limb hits the ground."

"Rear limb gait abnormalities may be evident as elevation of the hip (hip hike, gluteal rise), dropping of the hip (hip drop, gluteal drop). . . . elevation of the hip occurs when the horse shifts weight away from the lame limb during the weight-bearing phase of the stride . . . . dropping of the hip occurs if pain is most acute during the posterior phase of the weight-bearing portion of the stride."

These descriptions are similar in that they concentrate on the movement of pelvic structures, but they differ somewhat in the importance they place on the predominant movement (elevation or depression) characteristic of lameness. I have always found it difficult to understand the concepts "hip hike" and "gluteal rise." In horses with hindlimb lameness, it often appears that the pelvis "hikes" on the affected side, but it also appears sometimes that it "dips" or "hikes" and "dips" at different times during the stride of the lame limb. The rapid changes of the relative positions of the pelvic structures in a horse even at a slow trot (4 m/s) and the limited temporal resolution of the human eye make it difficult to appreciate the asymmetrical durations of pelvic movement described above. In general, the above descriptions, although not being incorrect, are complex and difficult to understand. In the next sections, I will describe the objective evidence for how the pelvis moves during hindlimb lameness using data generated with high-speed cameras and computer-assisted kinematic evaluation during controlled conditions. The more objective description of pelvic movement with lameness allows one to see that sometimes it is less downward movement, sometimes it is a less upward movement of the pelvis, and sometimes it is both that are important for the detection of hindlimb lameness.

3. Objective Analysis of Pelvic Movement in the Sound Horse and in the Horse With Unilateral Hindlimb Lameness

In a sound horse at the trot, the pelvis, as a whole unit, moves up and down twice during one complete stride. The vertical movement of the pelvis can best be appreciated by observing the movement of its most dorsal site between the tubera sacrale. At the beginning of stance, the pelvis is already moving down, along with the rest of the torso, at the end of the suspension or swing phase of the contralateral limb. It continues to move down, reaching a nadir or minimum position at full weight bearing when the limb is perpendicular to the ground at midstance. It then begins to move upward during the caudal one-half of stance, continuing its upward movement during breakover and pushoff and into the beginning of the swing phase of the stride when the horse is suspended in mid air with no limbs on the ground. It reaches a maximum position a short time before impact of the contralateral limb. After impact of the contralateral limb, this same sequence of downward and then upward movement occurs again. The key observations in this sequence are that there is downward followed by upward pelvic movement during stance and upward followed by downward pelvic movement during the swing phase of the stride. In the sound horse, the maximum and minimum pelvic positions during each one-half cycle of the stride are equal. One should notice that this description is equivalent to a description of vertical head movement in association with stance and swing phases of the forelimbs.

In the horse with a mild to moderate unilateral hindlimb lameness, this sequence is the same. There is downward and then upward movement of the pelvis during the stance phases of both the lame and sound hindlimbs, and there is upward and then downward movement of the pelvis after pushoff of both the lame and sound hindlimbs. The difference is in the relative pelvic heights at the midstance positions and after pushoff of the two hindlimbs.

It is the relative height of the pelvis during midstance (the downward movement) or after pushoff (the upward movement) that determines the side of lameness, but which one is more important? It is actually simpler than evaluation of the head for forelimb lameness.

Figure 1 is a graph of the expected vertical pelvic movement in a horse that is sound in the hindlimbs. Taking into consideration some expected stride-to-stride variability, the vertical movement of the pelvis is generally symmetrical over the stride cycle (i.e., the maximum and minimum pelvic positions during and just after stance, respectively, are the same during the left and right halves of the complete stride).

After evaluating many horses with mild to moderate unilateral hindlimb lameness, both natural and induced, we have observed the following patterns of movement. (1) The pelvis moves down during the stance phase of the lame limb, but the absolute height is higher than during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is the same as after pushoff of the sound limb (Fig. 2). (2) The pelvis moves down during the stance phase of the lame limb, but the absolute height is the same as during stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb (Fig. 3). (3) The pelvis moves down during the stance phase of the lame limb, but the absolute height is higher than during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb (i.e., a combination of patterns 1 and 2, Fig. 4).

The relative vertical movement of each side of the pelvis, represented by the up and down motion of the tubera coxae, are also used to detect hindlimb lameness in horses. The above textbook descriptions...
are similar to this method of evaluation. The vertical movement of the tuber coxae has the same basic pattern as the pelvis as a whole, moving up and down twice in one complete stride, but the movement in the sound horse is not symmetrical. The first minimum height occurs during the middle of the stance phase, and the first maximum height occurs after pushoff. The second minimum and maximum positions occur during stance and shortly after pushoff of the other hindlimb. However, total vertical movement of the tuber coxae is greatest during the stance phase of the contralateral hindlimb. The tuber coxae reaches its lowest height at midstance and its maximum height after pushoff of the contralateral hindlimb. This degree of asymmetry is increased in horses with unilateral hindlimb lameness. With lameness, the tuber coxae of the lame limb has less downward movement during the stance phase and less upward movement at the end and shortly after the stance phase of the lame limb.

Fig. 1. Sound pattern of vertical pelvic movement. Minimum vertical pelvic positions during the left- and right-stance phases, taking into consideration some expected stride-to-stride variability, are generally equivalent. Maximum vertical pelvic positions just after left- and right-stance phases are equivalent.

Fig. 2. Lameness in the deceleratory (first one-half) phase of the hindlimb stance (pattern 1). The pelvis moves down during the stance phase of the lame limb, but the absolute height is higher than during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the average absolute height is the same as after pushoff of the sound limb.
IN-DEPTH: LAMENESS IN MOTION

**Fig. 3.** Lameness in the acceleratory phase (second one-half) of hindlimb stance (pattern 2). The pelvis moves down during the stance phase of the lame limb, but the absolute height is the same as during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb.

During the stance phase of the sound limb, the contralateral tuber coxae (i.e., on the side of the lame limb) has more downward movement during and more upward movement after the stance phase of the sound limb. This increased upward movement after the stance phase of the sound limb may represent the often mentioned "hip hike." Total vertical tuber coxae movement, because of pelvic rotation during movement, is greater than total vertical movement of the pelvis as a whole unit (as visualized at the tuber sacrale), which may be easier for some individuals to observe. A simple but accurate description is that total vertical movement of the tuber coxae on the lame side is greater than total vertical movement of the tuber coxae on the sound side (Fig. 5).

There is, however, one caveat to the successful use of this method. This method can be misleading when the horse has pre-existing pelvic asymmetry, which can be assessed by observing the horse from

**Fig. 4.** Lameness in the deceleratory and acceleratory phases of hindlimb stance (pattern 3). The pelvis moves down during the stance phase of the lame limb, but the absolute height is higher than during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb.
the rear as it is standing squarely on the hindlimbs (Fig. 6). In horses with pre-existing pelvic asymmetry, whether or not the horse is lame, the total vertical movement of the tuber coxae will be greater on the lower side of the pelvis.

4. Pelvic Movement in Horses With Primary Hindlimb Lameness

It is possible for primary forelimb lameness to cause compensatory movements in the pelvis such that a false hindlimb lameness may be visible. However, this is not as apparent nor as common as the converse situation when a primary hindlimb lameness can cause compensatory movements in the head such that a false forelimb lameness (ipsilateral) is visible. In a recent study of 17 horses with induced forelimb lameness, it was apparent that a moderate to severe primary forelimb lameness could cause a slight, false hindlimb lameness. This effect was significant when evaluated over the entire group of 17 horses, but it was also apparent that this effect was variable when looking at the horses individually. Most horses with primary forelimb lameness had no observable change in pelvic movement, whereas some had moderate pelvic movement asymmetry. The side of the apparent but false hindlimb lameness depended on the direction that the pelvic movement was being observed. Generally, the pelvis moved down but to a greater height during the stance phase of the hindlimb contralateral to the primary forelimb lameness compared with the pelvic movement during the stance phase of the contralateral hindlimb (ipsilateral to the primary forelimb lameness). Thus, this would appear as a mild, false contralateral hindlimb lameness. Conversely, the pelvis moved up but to a lesser height after pushoff of the hindlimb ipsilateral to the primary forelimb lameness compared with the pelvic movement after pushoff of the contralateral hindlimb (contralateral to the primary forelimb lameness). This would appear as a mild, false ipsilateral hindlimb lameness. Watching out for false hindlimb lameness is a minor but important consideration during lameness evaluation in horses.

5. Types of Hindlimb Lameness and a Hypothesis on if Pelvic Movement Can Help Us to Further Localize Lameness Within the Hindlimb

A sound horse will move its pelvis up and down twice per stride in a symmetrical pattern such that frequency analysis of the vertical pelvic movement signal will yield a single frequency, which will be equivalent to twice the stride rate. Frequency analysis of the vertical pelvic movement signal in a horse with unilateral hindlimb lameness will yield two prominent harmonic frequencies: one, occurring at the stride rate, represents the lameness, and one, at twice the stride rate, represents the natural, inertia-driven, up-and-down movement of the pelvis as in the sound horse. However, the two-component model that so simply explains the various head-motion patterns in forelimb lameness does not explain the various pelvic-motion patterns in hindlimb lameness. This is because the back end of the horse cannot be thought of in the same way as the front (i.e., as two linked segments). In the rear one-half of the body, there is no "opposing" component counteracting the movement of the torso and hindlimbs. A single component model would be more appropriate. However, the vertical pelvic movement patterns can still tell us much about hindlimb lameness.

During the deceleratory phase of stance, which is the cranial one-half (from impact to midstance), the downward inertia of the pelvis is "damped" by the upper hindlimb musculature, resulting in less down-

Fig. 5. Total vertical movement of the tuber coxae is greatest on the lame hindlimb side. In this case, the lame side is the right side.

Fig. 6. This horse is standing squarely on the hindlimbs. The right side of the pelvis is "down" relative to the left. At the trot, the total vertical movement of the tuber coxae on the right side will be greater, regardless of the side of lameness.
ward motion of the pelvis. Thus, lameness with the most significant pain occurring in the cranial one-half of stance will result in the first pattern of pelvic motion described above. The pelvis will move down during the stance phase of the lame limb, but the absolute height will be higher than during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is the same as after pushoff of the sound limb.

As an example, a horse with mild distal tarsal arthrits caused by the shear strain on the distal tarsal joints will be greatest during the deceleratory (first one-half) phase of stance and will primarily exhibit less downward movement of the pelvis during stance (Fig. 7).

During the acceleratory phase of stance, which is the caudal one-half (from midstance through push-off), limb "pushoff" force is weak, and the pelvis is driven upward to a lesser extent than after pushoff of the sound limb. Thus, lameness with the most

### Right patellar ligament lameness

![Graph of right patellar ligament lameness](attachment:right-patellar-ligament-lameness.png)

Fig. 8. Lameness in the acceleratory phase of hindlimb stance (pattern 2). The pelvis moves down during the stance phase of the lame limb, but the absolute height is the same as during stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb.
significant pain occurring in the caudal one-half of stance will result in the second pattern of pelvic motion described above. The pelvis moves down during the stance phase of the lame limb, but the absolute height is the same as during stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb. As an example, Figure 8 shows the pelvic and right hindlimb foot height patterns from a horse with a right hindlimb lameness that was “blocked out” by regional anesthesia of the patellar ligaments. Because the patellar ligaments are maximally strained at the end of stance (in preparation for stifle flexion against a “fixed” patella), the pain or dysfunction is most apparent during limb pushoff, resulting in less pelvic height after the stance phase of the affected limb.

Pain in both the deceleratory and acceleratory phases of stance (i.e., throughout stance) will result in the third pattern of pelvic motion described above. The pelvis moves down during the stance phase of the lame limb, but the absolute height is higher than during the stance phase of the sound limb. The pelvis moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound hindlimb (i.e., a combination of patterns 1 and 2). The more severe the lameness, the more likely that pain will be significantly present throughout the stride. Because much is already known about the dynamic behavior of many anatomic structures with the equine limb (each a potential focus of lameness), knowledge of the instant of occurrence of peak lameness within the stride cycle may help further isolate the lameness within the limb.

References