Head Movement Pattern in Horses With Forelimb and Hindlimb Lameness

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The vertical head movement pattern in horses with forelimb 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, MS 65211; e-mail: keegank@missouri.edu. © 2005 AAEP.

1. Introduction
Most equine practitioners look at how the horse's head moves during a trot to help them diagnose lameness. It is a common and well-accepted maxim that horses with forelimb lameness will show a "head nod" (or "head bob"), but descriptions of the "head nod" are incomplete, varied, and sometimes conflicting. Objective and precise measurements of head movement in lame horses have been made in experimental studies. The observations from these studies tell much about what the "head nod" really is and how close evaluation of it 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 the "head nod" and then compare these descriptions to what has been determined by controlled objective analysis of the head movement patterns in sound and lame horses. In the latter part of this paper, I will comment on head movement patterns in horses with primary hindlimb lameness, and finally, I will introduce a hypothesis that the specific head 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
"As a result of lameness in a forelimb, the head will drop when the sound foot lands and rise when weight is placed on the unsound foot or limb." \(^1\)

"The head and neck elevate or rise when the lame forelimb is bearing weight or hits the ground and nod down or fall when the sound forelimb hits the ground. . . it is immediately obvious that the elevation of the head and neck is much easier to see than the head nod down . . . the horse appears to be elevating the head and neck just before the lame limb hits the ground, and then, during the later part of the support or stance phase, the head and neck nod down." \(^2\)

"Forelimb lameness is usually evident as a head bob: the head rises immediately prior to and during weight bearing of the lame limb. Conversely, the head drops as the sound limb contacts the ground and bears weight." \(^3\)

Each of these descriptions are similar in that they state clearly that the head moves upward during the weight-bearing phase of the lame limb and downward during the weight-bearing phase of the sound limb.
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Sound in Forelimbs

- Head height
- Right forelimb foot height

Fig. 1. Pattern of vertical head movement in a sound horse.

limb. Indeed, this is what actually happens in horses with severe forelimb lameness and what appears to happen to the naked eye during the trot in horses with mild to moderate forelimb lameness. The rapid movement of the limbs in a horse even at a slow trot (4 m/s) and the limited temporal resolution of the human eye cause it to appear as such. However, they are also somewhat different in their varied emphases on whether it is the upward or downward movement of the head that is easiest to see. In general, they are also somewhat simplified and, in so being, incomplete. In the next sections, I will describe the objective evidence for how the head moves during forelimb lameness using data generated with high-speed cameras and computer-assisted kinematic evaluation during controlled conditions. The more complete description of head movement with lameness allows one to see that sometimes it is the downward movement and sometimes the upward movement of the head that is important for the detection of forelimb lameness. Quite possibly, a more complete and discriminating evaluation of head movement can help us isolate lameness within the lame limb.

3. Objective Analysis of Head Movement in the Sound Horse and in the Horse With Unilateral Forelimb Lameness

In a sound horse at the trot, the head moves up and down twice during one complete stride (Fig. 1).

At the beginning of stance, the head is already moving down along with the rest of the torso and following the contralateral suspension or swing phase. 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 head movement occurs again. The key observations in this sequence of events are the downward followed by upward head movement during stance and upward followed by downward head movement during the swing phase of the stride. In the sound horse, the maximum and minimum vertical head positions during each one-half cycle of the stride are equal.

In the horse with a mild to moderate unilateral forelimb lameness, this sequence of downward and upward head movement is the same. There is downward and then upward movement of the head during the stance phases of both the lame and sound limbs, and there is upward and then downward movement of the head after pushoff of both the lame and sound limbs. The difference is in the relative head heights at the midstance positions and after pushoff of the two forelimbs. This relationship breaks down in horses with severe lameness when the movement of the head during stance may be first upward and then downward or when the head maximum position is reached before the end of stance. The purpose of this manuscript is not to describe the head movement patterns in horses with severe forelimb lameness; accurate detection of this lameness is not difficult.

Therefore, the relative height of the head during midstance (the downward movement) or after pushoff (the upward movement) determines the side of lameness, but which one is more important? It is not so simple.
After evaluating many horses with mild to moderate unilateral forelimb lameness, both natural and induced, we have observed the following patterns of movement: (1) The head 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 head moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound limb (Fig. 2). (2) The head 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 head moves upward after pushoff of the lame limb, but the absolute height is the same as after pushoff of the sound limb (Fig. 3). (3) The head 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 head moves upward after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound limb (Fig. 4). (4) The head 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 head moves upward after pushoff of the lame limb, but the absolute height is the same as after pushoff of the sound limb.
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**Right forelimb Lameness - pattern 3**

- Head height
- Right forelimb foot height

Fig. 4. Pattern 3. The head 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 head moves up after pushoff of the lame limb, but the absolute height is higher after pushoff of the sound limb.

There is an old adage “down on sound,” which means that the head moves down to a lower height during the stance phase of the sound limb. Judging from the patterns that we have seen, this statement is not always correct. “Down on sound” would pick the correct limb in the first three patterns described above, but pattern four would be evaluated as sound. The head never moves down to a lower position during stance phase of the lame limb compared with the sound limb, so if this is observed, the correct limb can always be identified. “Down on sound” is generally a good way to observe forelimb lameness.

Evaluation of the head movement upward is more difficult but, as we will discuss later, potentially

**Right forelimb lameness - pattern 4**

- Head height
- Right forelimb foot height

Fig. 5. Pattern 4. The head 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 head moves up after pushoff of the lame limb, but the absolute height is higher after pushoff of the sound limb.
very informative for isolating forelimb lameness. Sometimes the head reaches a maximum position after pushoff of the lame forelimb that is sometimes higher, sometimes lower, and sometimes the same as that after pushoff of the sound forelimb.

One could argue that it is the relative excursion of the head rather than the absolute height that one should be watching when evaluating for forelimb lameness. If this is the case, then the four patterns described above are the same but can be rephrased in excursion terminology. (1) The head moves down the same amount during the stance phases of the lame and sound limbs, but it moves up less after pushoff of the lame limb compared with pushoff of the sound limb. (2) The head moves down less during the stance phase of the lame limb than during the stance phase of the sound limb, and it moves up less after pushoff with the lame limb compared with pushoff of the sound limb. (3) The head moves down less during the stance phase of the lame limb than during the stance phase of the sound limb, but it moves up the same amount after pushoff of the lame and sound limbs. (4) The head moves down less during the stance phase of the lame limb than during the stance phase of the sound limb, and the head moves up more after pushoff of the lame limb than after pushoff of the sound limb. These descriptions are more difficult to understand and, as we shall see later, are more problematic for detection of lameness, which may result because of variations in lameness severity and time of occurrence.

4. Head Movement in Horses With Primary Hindlimb Lameness

It has been well described in textbooks and in objective, controlled studies that horses with primary hindlimb lameness can appear to have ipsilateral forelimb lameness.\(^1\)\(^4\)\(^5\)\(^7\)\(^8\)\(^9\) This is because the horse uses its head movement to help reduce load on the lame hindlimb, moving it down to a lower position when the lame hindlimb is in stance. Using the "down and sound" maxim, it seems that the horse has a forelimb lameness ipsilateral to the true hindlimb lameness. The question is how often does this happen and how likely is it for a practitioner to "mistake" a forelimb lameness for an ipsilateral hindlimb lameness. In a recent study of 17 horses with induced hindlimb lameness, it was apparent that rather mild, primary hindlimb lameness frequently caused a more apparent and severe but false ipsilateral forelimb lameness.\(^1\)\(^0\) 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. Some horses with primary hindlimb lameness had very little change in head movement, whereas some had dramatic head movement asymmetry. An individual horse's body conformation may be a discriminating factor. Watching out for ipsilateral, false forelimb lameness is an important consideration during lameness evaluation in horses. This author on occasion has spent days blocking out suspected forelimb lameness only to find the true primary hindlimb lameness.

5. Types of Forelimb Lameness? Can Head Movement Help Us to Further Localize Lameness Within the Forelimb? A Hypothesis

A sound horse, with no extraneous, random, vertical head movement, will move its head up and down twice per stride in a symmetrical pattern such that frequency analysis of the vertical head movement signal will yield a single frequency; this will be equivalent to twice the stride rate.\(^4\) Frequency analysis of the vertical head movement signal in a horse with unilateral forelimb lameness will yield two prominent harmonic frequencies: one representing the lameness, occurring at the stride rate, and one at twice the stride rate representing the natural, inertially driven, up and down movement of the head, as in the sound horse. Each of the above, previously described four different head movement patterns, although they seem quite different, represent a continuum in the temporal relationship between the two harmonic components that make up vertical head movement in a trotting horse with unilateral forelimb lameness. The frequency amplitude spectrums of each pattern are identical, but the phase differences between the two predominant harmonic frequencies vary.

Pattern 1: the head moves down during the stance phase of the lame limb but the absolute height is lower than during the stance phase of the sound limb; the head moves up after pushoff of the lame limb, but the absolute height is lower than after pushoff of the sound limb. This pattern results when the two predominant harmonic frequencies are out of phase (i.e., their phase difference is 0°). When the phase difference is 0°, the peak or maximum of the lameness component, which can be thought of as the time of maximum pain or discomfort during the stride, coincides with the beginning of stance. Thus, this is the pattern of head movement expected when lameness is "felt" by the horse primarily during impact of the forelimb (Fig. 6).

Pattern 2: the head 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 head moves upward after pushoff of the lame limb, but the absolute height is the same as after pushoff of the sound limb. This pattern results when the two predominant harmonic frequencies are out of phase by 90°. When the phase difference is 90°, the peak or maximum of the lameness component coincides with midstance. Thus, this is the pattern of head movement expected when lameness is "felt" by the horse primarily during full weight bearing on the limb, which occurs at midstance (Fig. 7).

The difference in the downward positions of the head increases and the difference in the upward positions of the head decreases as the phase difference varies from 0°–90° or from impact to full weight
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Fig. 6. Head-movement components in phase (phase difference = 0°). The peak of the lameness component occurs at the instant of the right forelimb hoof impact (arrows). Note the less downward and less upward movement of the head during and after stance of right forelimb. Black horizontal bars, right forelimb stance; blue signal, lameness component; red signal, natural vertical head movement component; purple signal, sum of blue and red signals.

Pattern 2: the head 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 head moves up after pushoff of the lame limb, but the absolute height is higher than after pushoff of the sound limb. This pattern results when the two predominant harmonic frequencies are out of phase by 90–180°. When the phase difference is between 90–180°, the maximum of the lameness component occurs between midstance and the end of stance. Thus, this is the pattern of head movement expected when lameness is “felt” by the horse primarily during the initial swing part of the stride, after pushoff of the sound limb. This pattern results when the two predominant harmonic frequencies are out of phase by 270°. When the phase difference is between 180° and 270°, the maximum of the lameness component occurs after breakover at the end of the stance phase of the stride. Thus, this is the pattern of head movement expected when lameness is “felt” by the horse primarily during the initial swing part of the stride when the limb is not weight bearing (Fig. 9).

The difference in the downward position of the head decreases and the difference in the upward position of the head increases as the phase difference varies from 90–270° or from full weight bearing through pushoff (in the acceleratory part of the stance phase of the stride) and into the beginning of the swing phase of the stride.

The two-component model of vertical head movement for diagnosis of lameness is plausible, because the front end of the horse can be thought of as two linked segments (the torso-leg and the head-neck segments). Movement in the head-neck segment

Fig. 7. Head-movement components out of phase (phase difference = 90°). The peak of the lameness component occurs at midstance (arrows). Note the less downward movement of the head during stance but the same upward movement at the end of stance. Black horizontal bars, right forelimb stance; blue signal, lameness component; red signal, natural vertical head movement component; purple signal, sum of blue and red signals.

Fig. 8. Head-movement components out of phase (phase difference between 90° and 180°). The peak of the lameness component occurs at the end of stance (arrows). Note the less downward movement of the head during stance but greater upward movement of the head at the end of stance. Black horizontal bars, right forelimb stance; blue signal, lameness component; red signal, natural vertical head movement component; purple signal, sum of blue and red signals.

Fig. 9. Head-movement components out of phase (phase difference = 270°). The peak of the lameness component occurs after the end of stance (arrows). Note that there is no difference in downward movement of the head but greater upward movement of the head after the end of the stance. Black horizontal bars, right forelimb stance; blue signal, lameness component; red signal, natural vertical head movement component; purple signal, sum of blue and red signals.
will always try to reduce force on the torso-leg segment. Because much is already known about the dynamic behavior of many anatomic structures within 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. For example, limb vibration, as opposed to a total force applied to it at any one instant, is known to cause specific arthritic and other musculoskeletal disorders in humans.\(^1\) In the horse at limb impact, a significant proportion of the vibration occurring to the limb is attenuated or damped within the joint structures.\(^12\) Therefore, arthritic conditions would be expected to show patterns of head motion. Figure 1 depicts the head-motion pattern in a horse with experimentally induced carpal arthritis. Similarly, it is known that at the instant of hoof impact at the beginning of the stance phase, the force on the hoof is small, but it experiences high-frequency vibration. This vibration is damped predominantly by the lamina of the foot. Lamellar pathology could, therefore, also be expected to cause maximum pain response at hoof impact, leading to head-motion pattern 1.

Another example is that the navicular suspensory ligament is known to be strained maximally during breakover.\(^13\) Injury or lameness to the navicular suspensory ligament could be expected to cause pain during breakover, leading to head movement like pattern 3. Figure 3 is an actual example of the head-motion pattern of a horse with calcification of the navicular suspensory ligament seen on radiographic examination of the foot. This horse also “blocked out” (i.e., the vertical head movement pattern became temporally symmetric) after a palmar digital nerve block. Similarly, the inferior check ligament is known to be strained maximally during breakover,\(^14\) and injury to the inferior check ligament could be expected to result in a similar head-motion pattern. Other anatomic structures are known to be maximally stressed at full weight bearing or activated during the swing phase of the stride, leading to head-motion patterns 2 and 4, respectively. Knowledge of when pain is maximally occurring during the stride, obtained from close analysis of the specific head movement pattern, would be immeasurably beneficial to equine practitioners attempting to narrow the differential diagnosis in specific lameness cases. With practice, close visual analysis of the specific head-motion patterns can potentially ascertain these different head movement patterns.

References