Lameness in horses is most effectively understood by studying vertical motion of the torso. Vertical motion of the torso follows and therefore mimics the reduced ground reaction forces that occur (and are understood on physical first principles) with lameness. Forelimb movement, especially during the swing phase of the stride, is highly dependent on “other” factors besides lameness, most notably anatomical conformation. Timing of lameness, in other words whether maximum pain occurs during impact (first ½ of stance) or pushoff (second ½ of stance), may also affect limb movement. As an example consider amplitude of forelimb protraction. Decreased forelimb protraction is frequently proposed as a sensitive general indicator of forelimb lameness. Horses with navicular disease frequently display this restricted motion to avoid normal heel-first landing. Yet, horses with laminitis, or pain primarily in the dorsal region of the foot, display the opposite, or increased protraction. The dependence of forelimb movement pattern on timing of lameness indicates that this parameter is not present in all forelimb lameness, so there is a potential for “false negatives” and “false positives” when using forelimb movement to detect and evaluate forelimb lameness in horses. Also, determination of an absolute decreased or increased amplitude of movement, whether it be in the limbs or torso, requires high spatial resolution, which degrades with distance from source. Very small decreases in “normal” movement cannot be reliably detected by the naked human eye. Research has shown that the most reliable indicator of lameness it to detect asymmetric pattern of movement. Asymmetric movement of the torso is the reliable indicator of lameness in quadrupeds.

The concept of using vertical motion of the torso as the primary indicator of lameness in quadrupeds is relatively straight forward to understand. To reduce force on a painful forelimb during weight bearing (since force = mass x acceleration), the animal causes the torso to fall less than normal. The mechanism most available to the horse is to use the head. It is a large counterweight on a first class lever arm. Another way to conceptualize the relationship of head to “rest of body” movement is a 2-component free body system (see below). The head will always be moved upward (by the neck muscles) to reduce peak vertical ground reaction force (against the mass of the body) applied through the affected forelimb.

Figure 1: Two-component model of vertical head and “rest of body” movement in the trotting horse

The classic “head nod” depicts that in a lame horse the whole front of the torso (including the head) moves down when the good (not lame) limb is on the ground, and then up when the lame limb is weight bearing. This is an extreme simplification that is really only true in horses with severe lameness. But, in horses that are trotting, the head must follow the center of mass of the body, which moves down when the horse is landing on a limb and then up when the horse pushes off that limb. This downward and then upward movement repeats itself when the opposite limb lands and then pushes off. So, a horse moves its head down and then up twice in one complete stride, whether it is lame or not. The head does not just move up during the stance phase of the lame limb and down during the stance phase of the sound limb. So where does this maxim “down on sound” come from?

Examining the different shapes of the trajectories of vertical head movement as forelimb lameness increased reveals the origin and context of this maxim. With very mild lameness the asymmetry of the normal down and then up movement (twice per stride) is small, so maybe there is just a little less downward motion of the head (upper left figure 1) during lame limb stance. As the lameness is increased, this asymmetry is increased, the overall shape of the vertical head movement trajectory (upper right and lower left figure 1), which is down and then up, is retained. Eventually, as the amplitude of lameness is increased, this asymmetry in downward and then upward movement of the head increases to a point where movement of the head due to lameness overtakes, or swamps, this normal overall pattern following the downward and then upward movement of the center of mass of the body. This is a simple wave summation phenomenon. At this last stage (lower right figure 1) the horse is very lame and it is only now that the predominant pattern of head movement truly is upward only during the stance phase of the lame limb and downward only during the stance phase of the sound limb. Thus, this maxim, “down on sound”, is only true for detecting lameness in horses with severe lameness. So, in the practical sense, it is not useful.

Figure 2: Vertical head trajectory with gradually increasing (A-D) forelimb lameness

But, what then should one look at to detect forelimb lameness? Should then one look at total excursion of the head, or its total distance of movement from a high to a low position, or should one look at the end position relative to the ground after this movement? The maxim, “down on sound”, would also suggest that you should look at excursion, but this is incorrect. However, experimental evidence and physical first principles suggests the later will always be true. One should look at position. The maxim should more
specifically state “low on sound”, not down on sound. In most forelimb lameness the head reaches its lowest position when the sound limb is on the ground.

Examining this a little more closely, and hinted at earlier, shows quite simply that there are two, you could say competing, reasons that a horse moves it head down and then up during a trotting stride. The first is simply the head following the center of mass of the body as it moves down and then up during a stride at the trot. The second, which is only present with lameness, and which occurs at half the frequency (if the lameness be unilateral), is the head moving away, that is upward, from the affected limb with maximum amplitude or intensity at the time of peak pain during the stride (impact, midstance, pushoff). The head also moves backward for the same reason but this is not important to understand the phenomenon. Movement of the head upward will always reduce force on the forelimbs.

Experimental evidence has shown that the pattern seen most commonly in horses trotting at relatively slow speed, without a rider and moving in a straight line, displays an asymmetry in both high and low positions of the head. Let us first consider a lameness in the first part of stance, which is the decelerating phase of stance (the torso is moving down and decelerating). The horse moves it head up more than normal during pushoff of the good limb so that its head is at a maximum height at the beginning of lame limb stance. In more severe lameness the head may actually be still accelerating upward (though the torso is decelerating downward) as the lame limb hits the ground. This effectively reduced load on the limb during the first part of stance. The head then falls during the lame limb stance but less than it normally would have fallen if the limb was not painful. The total distance of this fall, because the fall started from such a high position, may actually be larger than that that occurs during the stance phase of the non-lame limb. But the fall is aborted (damped may be a better word) so that its lowest position (which occurs about midstance) is higher than the low position at midstance of the non-lame limb. So, “low on sound” picks the correct limb, but “down on sound” does not. As the lameness (or time index of the amplitude of peak pain) shifts from early stance, through midstance, into late in stance (end of stance), the head continues to fall less than it normally would have fallen, but the pattern of upward movement of the head begins to change. With lameness in the second half of stance (the impulsion or acceleration phase) the head begins to move up more than it normally would have. Thus, in addition to “low on sound” the horse displays an “up on bad”, or “high on bad” vertical head movement pattern. Notice, that this is just the opposite for a lameness that occurs during the first half of stance, during which the horse will move its head up more pushing off the good limb.

Based on all these studies, this is what I now teach students about how to detect and evaluate forelimb lameness. First, avoid getting sidetracked by concentrating on the limbs, second, start always with “low on sound” not “down on sound”. If you cannot tell for certain using this method then either revert to “up on bad” or “high on bad”, and not the other way around. Do not start with “up on bad” first, or you may miss horses with strong impact type lameness.

Core information in support of these proceedings can be found in the following manuscripts and text chapters

References