Components of COLLECTION

Understanding the biomechanics of your horse's stride will help you with his training.

By Hilary Clayton, BVMS, PhD, MRCVS

Collection is the apex of the pyramid of training—the ultimate goal of training the dressage horse. According to the FEI (Fédération Equestre Internationale) rules for dressage, the aims of collection are: to develop and improve the horse's balance and equilibrium; to develop and increase the horse's ability to lower and engage the hindquarters for the benefit of the lightness and mobility of the forehand; and to improve the ease and carriage of the horse, making him more pleasurable to ride. One of the research projects I oversee at the McPhail Equine Performance Center is analyzing how the horse achieves collection and which muscles need to be strengthened to facilitate performance of the movements in collection and self-carriage. In this article, we'll take a look at the relationship between the technical requirements of collection and the associated biomechanical characteristics.

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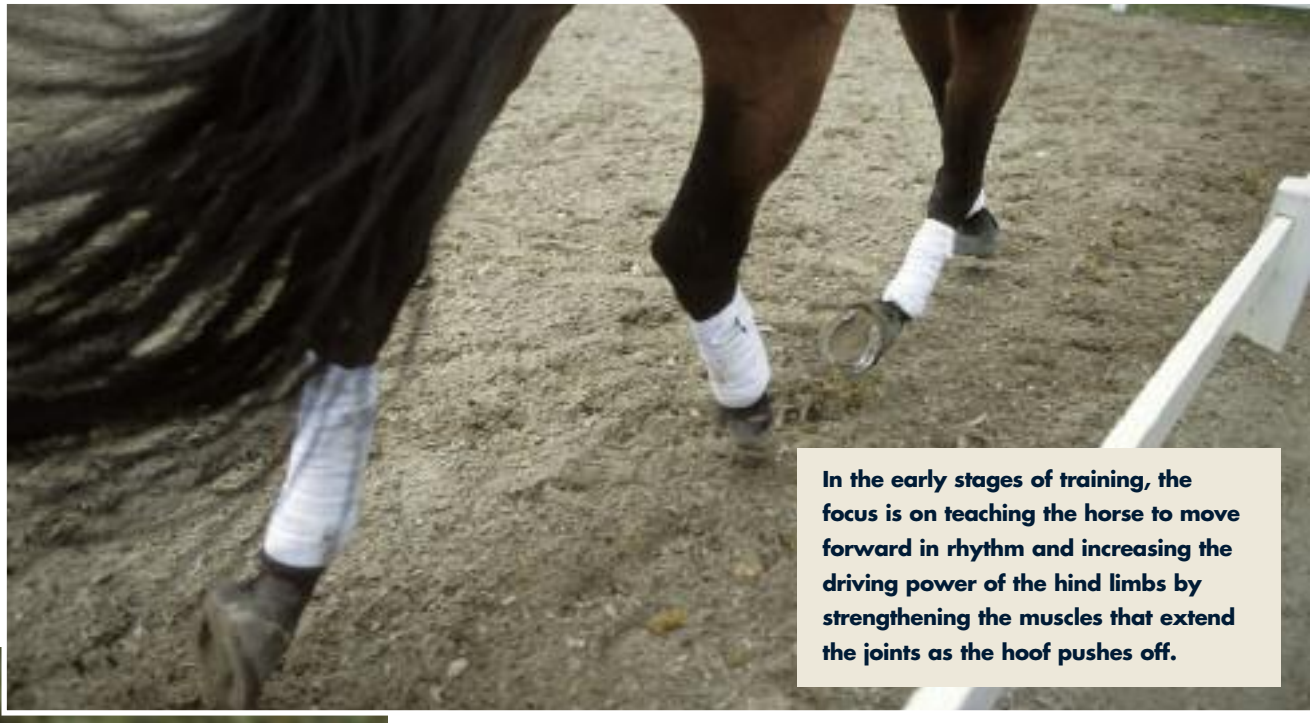

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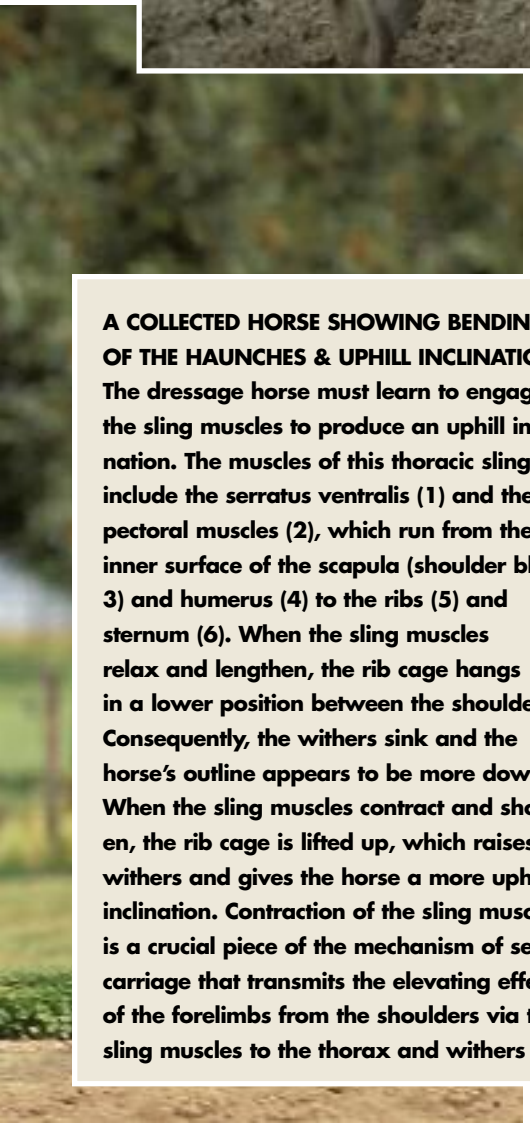

A COLLECTED HORSE SHOWING BENDING OF THE HAUNCHES & UPHILL INCLINATION
The dressage horse must learn to engage the sling muscles to produce an uphill inclination. The muscles of this thoracic sling include the serratus ventralis (1) and the pectoral muscles (2), which run from the inner surface of the scapula (shoulder blade, 3) and humerus (4) to the ribs (5) and sternum (6). When the sling muscles relax and lengthen, the rib cage hangs in a lower position between the shoulders. Consequently, the withers sink and the horse's outline appears to be more downhill. When the sling muscles contract and shorten, the rib cage is lifted up, which raises the withers and gives the horse a more uphill inclination. Contraction of the sling muscles is a crucial piece of the mechanism of self-carriage that transmits the elevating effect of the forelimbs from the shoulders via the sling muscles to the thorax and withers (7).

The Relationship Between Forces and Movements

In order to understand collection, we need to start by reviewing the fundamental relationship between forces and movements. Locomotion occurs as a result of the hooves pushing against the ground to generate forces; without these forces, there is no movement. The forces generated by the hooves determine the speed and direction of movement: the harder the hooves push, the faster the body moves.

The horse moves in the opposite direction from the push of the hooves:

- the hoof pushes downward to lift the body upward into a lofty suspension;
- the hoof pushes backward to propel the body forward into a powerful extension;
- the hoof pushes to the right to turn the body to the left or to move sideways in a half pass to the left.

At the McPhail Center, we are able to measure the force of the hoof pushing against the ground in different gaits and movements using a piece of equipment called a force plate. This is a metallic plate measuring 2 feet by 4 feet that is covered by non-slip rubber matting and embedded in a rubberized runway. When a horse is ridden over the force plate, we can measure adjustments in the way the hooves push against the ground to change the length or elevation of the stride.

One of the things we've learned from our studies is that there is definitely a division of labor between the fore and hind limbs. The hind limbs are the engine, providing most of the propulsion, and the back transmits the propulsive forces forward to the forehand. The forelimbs are designed to control speed, turn the body and adjust the horse's balance. As the degree of collection increases and the horse's self-carriage improves, the back muscles are recruited to lighten the forehand. All parts of the body must work together in harmony to produce a balanced picture.

The different functions of the fore and hind limbs are reflected in confor-

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This horse's conformation is described as downhill because the croup is higher than the withers. This type of conformation is less than ideal for dressage because it is difficult to raise the withers high enough for the horse to move uphill. The neck is set on lower and comes out of the shoulder with less elevation than in the warmblood above.

mational differences in their joint angles. The angulation of the stifle and hock joints allows them to flex as the hind limb accepts weight and then to extend powerfully to generate propulsion. In contrast, the fact that the forearm and cannon bone are aligned during weight-bearing allows the forelimb to act as a strut that vaults the shoulders upward. An interesting feature of the forelimb anatomy of horses is that they do not have a clavicle or shoulder girdle, so there is no bony connection between the forelimb and the body. Instead, there are strong muscles that suspend the trunk between the two scapulae in a sling-like arrangement.

The muscles of this thoracic sling include the serratus ventralis and the pectoral muscles, which run from the inner surface of the scapula and humerus to the ribs and sternum. When the sling muscles relax and lengthen, the rib cage hangs in a lower position between the shoulders. Thus, the withers sink and the horse's outline appears to be more downhill. When the sling muscles contract and shorten, the rib cage is lifted, raising the withers and giving the horse a more uphill inclination. Contraction of the sling muscles is a crucial piece of the mechanism of self-carriage that transmits the elevating effect of the forelimbs from the shoulders (scapulae) via the sling muscles to the thorax and withers. The dressage horse must learn to engage the sling muscles to produce an uphill inclination.

Action of the Limbs During the Stride

During a complete stride, each limb has a stance phase when the hoof is on the ground and a swing phase when the hoof is swinging forward. Our eyes are naturally drawn to watch the movement during the swing phase, when we see the joints flexing to raise the hoof clear of the ground as the leg swings forward. The limb movements during the swing phase give expression to the stride, especially when the leg is reaching forward.

During the stance phase, the hoof pushes against the ground to move the horse's body. The actions of the limb during stance are actually more impor-

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A levade at the Spanish Riding School in Vienna

tant in determining the quality of the gaits than the movements during the swing phase. After the hoof hits the ground at the start of the stance phase, the joints of the hind limb flex to absorb concussion. Horses vary in how much the hip, stifle and hock joints flex and in how long that flexion is maintained. Ideally, we want to see a lot of flexion maintained through the middle part of the stance phase. This flexion is sometimes described as "bending the haunches." The term bending refers to the smaller angles at the hip, stifle and hock joints when they are flexed. The effect of bending the haunches is to shorten or compress the hind limb as a whole, which results in lowering of the croup.

In the later part of stance, the hip, stifle and hock joints extend as the hoof pushes off against the ground to generate propulsion. Stronger muscles are able to push harder and generate the necessary forces more rapidly, so the hoof spends less time in contact with the ground. Consequently, as the muscles get stronger and the hooves need less time on the ground to develop impulsion, the stance phase becomes shorter and the horse's movement looks less grounded. This is particularly important in highly collected movements like the pirouettes and piaffe, in which horses that are not yet strong enough tend to look stuck to the ground. The expression "to make the horse quicker behind" is not a quickening of the tempo, rather it is an encouragement to get the hind hooves off the ground more quickly. In order to do this, the muscles must be strong enough to push harder and generate the required forces more rapidly.

The contribution of the forelimbs in achieving collection has received less attention than that of the hind limbs, but it is equally important. The increase in hind limb propulsion that occurs as the muscles get stronger tends to push the horse's balance onto the forehand. The amount of propulsion from the hind limbs must be balanced by the action of the forelimbs pushing the withers upward and backward to prevent the tendency to roll over the forehand. Without the balancing effect of the forelimbs, increased propulsion from the hind limbs would simply push the horse more onto his forehand.

The horse's back is also an essential part of the self-carriage equation. The back as a whole must be sufficiently rigid to transmit propulsive forces forward from the hind limbs to the forehand. If the back were rubbery, it would not be effective for force transmission. A system of short (multifidus) muscles that lie adjacent to the vertebrae are particularly important for stabilization. As the horse progresses through dressage training and reaches a higher level of self-carriage, the long (longissimus) muscles that lie beneath the skin on either side of the spine assist in lifting the forehand. This action is particularly evident in the pirouettes and piaffe, movements in which there is great collection and obvious lightness of the forehand but little if any forward motion. The lifting action of the back muscles was clearly evident in our research on the levade, in which the forehand was lifted up from behind rather than being pushed off the ground by the forelimbs. Once the levade was established, the horse maintained his position by using the long back muscles, which requires tremendous strength.

The head and neck together account for about 10 percent of the horse's body mass, which represents about 150 pounds in a large warmblood. Movements of the neck have a large effect on the way the hooves push against the ground. This is illustrated by the nodding motion used to relieve weight-bearing on a painful forelimb in a lame horse: The head and neck are lowered as the sound forelimb accepts weight, then raised as the sound forelimb pushes off. This has the effect of increasing the force against the ground during push-off. Consequently, the sound forelimb pushes harder and takes on most of the responsibility for raising the body, and this allows the forces on the lame limb to be reduced. Dressage horses that are not strong enough to use their long back muscles to elevate the forehand in the pirouettes and piaffe sometimes compensate by raising their heads and necks in rhythm with the push-off phase. For example, in the canter pirouette, the head and neck may be raised as the leading forelimb pushes off or, in piaffe, the head and neck may be raised as the weaker forelimb pushes off. In both examples, the effect is to use the upswing of the head and neck to assist in elevating the forehand.

Propulsion & Carrying Ability

In the early stages of training, the focus is on teaching the horse to move forward in rhythm and increasing the driving power of the hind limbs by strengthening the muscles that extend the joints as the hoof pushes off against the ground. These muscles are responsible for providing the forward propulsion

needed to adjust speed and stride length and to provide the upward propulsion that determines the loftiness of the stride and the amount of suspension.

The increased pushing power of the hind limbs can easily push the horse onto the forehand, however, so there must be an equivalent increase in strength of the muscles in the forelimb to maintain the elevation of the forehand and keep the horse balanced.

After the muscles have become strong enough to provide the necessary propulsion, the focus shifts to developing the carrying ability of the hind limbs. In this phase of training, the hind limbs continue to drive the horse forward and upward, but there is more bending of the haunches during the phase of weight acceptance in early stance, which requires a different type of muscular strength. At the same time, the forelimbs elevate the shoulders and the sling muscles transmit this elevation to raise the withers. The net effect of lowering the haunches and raising the withers is a more uphill inclination of the entire horse—collection.

Dr. Clayton will be one of the presenters at the U.S. Dressage Federation's Annual Convention, Nov. 28–Dec. 2, in Orlando, Florida. The Web site is usdf.org.

***Dr. Hilary Clayton** has held the Mary Anne McPhail Dressage Chair in Equine Sports Medicine at Michigan State University's College of Veterinary Medicine since 1997. She is also on the faculty of the Dept. of Large Animal Clinical Sciences. A lifelong rider, she is an active dressage competitor through the FEI levels. Thanks go to The Dressage Foundation for its recent funding of studies on the role of the forelimbs and self-carriage. Find out more about Dr. Clayton's research and how to make donations at the Web site cvm.msu.edu/dressage.*