The Physics of Collection

An engineer explains the mechanics of a collected horse.

By Anne Crowell

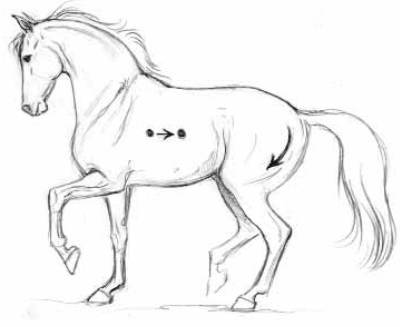
As an engineer by training, with a minor in physics, I have a need to understand how things work mechanically. In my article "The Physics of Flexion" (*DT*, Sept. 2010), we explored the workings of longitudinal flexion and its physical benefit to the horse. A flexed topline that allows the horse's back to swing and the musculature to operate efficiently must be maintained at all times if the horse is to carry the added weight of the rider easily. In this piece, we will delve into the biomechanics of collection and the physical processes that occur in the horse.

Barbara Greber

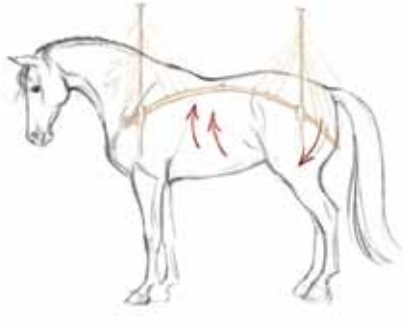
Bruno Greber rides Amidala, a Hanoverian mare owned by Ashanti Farm, demonstrating the engagement and topline necessary for collection.

What is True Collection?

Collection is a state in which the horse has developed strength in the hindquarters due to correct, progressive training. He uses this strength to lighten the forehand and carry more weight on his hind legs. The results of correct collection are 1) improved balance and poise, 2) an increased ratio of lift to thrust that produces elevated steps, and 3) lightening of the forehand with the poll at the highest point. The development of true collection is a long-term process. Forcing horses into collection before they are ready can be counterproductive and damaging (*Kottas on Dressage,* Kottas).



1. Center of mass (COM); relative elevation



2. The back as a bridge

Illustrations by Sandy Rabinowitz

Biomechanically, four things must happen for the horse to collect:

1. He must raise his head and neck to help shift the center of mass (COM) toward his hindquarters.
2. He must lift the base of his neck and raise his withers.
3. He must rotate his pelvis and bring his hind legs up under his COM.
4. He must maintain the tension in his supraspinous ligament (SSL), which runs along the top of the spine, so that his back remains elevated and his locomotion muscles can operate correctly.

The horse's center of mass can be thought of as the average position of his total mass. It acts as his balance point and is located near the heart girth and slightly forward of the midline of his body (Illustration 1, above). The position of the head and neck influences the position of the COM. Lowering the head pulls the COM slightly forward, while raising the head shifts it toward the hindquarters. In order for a horse to lift and lighten the forehand, the hind legs must come under the body so his ability to lift is enhanced.

The following is a fun experiment that will convince you that this is so. Get down on all fours, hollow your back down and rotate your legs so that your knees are out behind your hips. Try lifting yourself up. It's impossible.

Now, rotate your pelvis, and bring your knees up under your body and lift. It is now easy to lift your hands and lighten your forehand. The same is true for the horse. If you want him to elevate his forehand, his hind legs must be under his body close to the line of his COM.

Key Point 1: Biomechanically, the position of the haunches plays the most important role in achieving true collection.

How the Back Works

The horse's back is a bridge (illustration 2), and it receives and transmits the thrust from his hindquarters. In order

to support and carry the rider, the horse must maintain a positive tension in his supraspinous ligament/nuchal cord (SSL). Proper tensioning in the SSL allows the long back muscle to function correctly as a locomotion muscle. The long back muscle (M. longissimus dorsi) is not meant to hold the rider's weight. The tensioned SSL supports the rider's weight.

There are two main control points that regulate the tension in the ligament. They are the position of the head and neck and the position of the haunches. To tension a ligament, you must pull it on both ends. If you doubt this, just get a piece of rope and ask a friend to hold one end. To tension the rope you both must pull back. If one of you fails to pull, the rope will remain slack. The position of the horse's head and neck strongly influences the tensioning in the SSL.

Allowing the horse to stretch down and forward tensions the nuchal cord/SSL and lifts the horse's back (Illustration 3, p. 66). This is the frame in which young horses begin their riding careers. It allows them to maintain a correctly flexed topline, which supports the rider's weight and permits their backs to swing. In this longer frame, topline flexion is regulated by the extended position of the head/neck, which causes a substantial pull on the SSL. In this position, the horse's neck muscles do minimal work in keeping the back raised. This ability is the result of the evolution of the horse as a grazing animal. The horse's trunk is extremely heavy and requires substantial support, which comes from a properly tensioned SSL. A grazing horse expends a minimum of energy maintaining a lifted back and supported trunk. If the horse was not a grazing animal and lacked this unique ligamental structure, he would be incapable of carrying a rider's weight. (*Tug of War*, Heuschmann).

As training progresses and the horse

Try This Exercise to Develop Collection

By Bruno Greber

Barbara Greber

Greber on Amidala

The purpose: To encourage the horse to lift up through his withers while maintaining a positive tension in the SSL. Remember that the correct bend gives us better access to the different sections of a horse's body. When he bends correctly, the rib cage shifts so that the sternum moves up slightly. It is important for the horse to lift the back as he bends. The lift provides room for the pelvis to come farther under the horse and rider. Remember, when the rib cage is rigid, the hind leg can't easily swing under.

Also, the exercise helps to remind the rider to focus on the whole horse. The rider must maintain constant awareness of the horse's position while developing collection. Of utmost importance are the horse's flexion and bend, the position of the haunches and the overall frame.

The pattern: Begin by riding a 15-meter half-circle in haunches-in (travers) at A or C. Ride down the long side on the second track in shoulder-in. Ride another half-circle in haunches-in at A or C. Finish by riding shoulder-in again on the second track. Try it at walk, trot and canter.

The rider's checklist:

1. The inner leg asks for the bend, encouraging the horse to lift through his rib cage and withers.

2. Use the outside rein to position the horse's neck in a round outline and to determine the amount of flexion and bend that are necessary.

3. The outer rein adjusts the head and neck position as needed to ensure proper topline position while performing the pattern.

4. The inside rein establishes flexion and keeps the horse's mind focused.

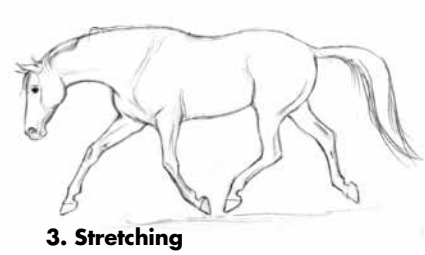
5. The outside leg keeps the horse's hind legs on the desired track.

Note: Make sure the horse never changes his lateral shape as he moves between the four phases. Keep flexion and bend the same throughout.

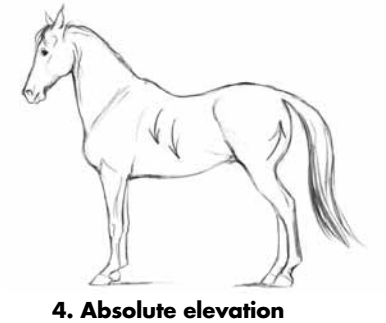
Tips: Don't exaggerate the angle during transitions. You want the haunches-in on four tracks but only as much as is needed to have equal space between the track lines of each hoof. • Give your horse time to make transitions. Focus on rhythm, tempo and balance. • Don't fatigue your horse. Frequent changes between the challenging movements and movements with moments of release will help keep him motivated and add to the effectiveness of the exercise. • Don't drill. Just do a little as part of a routine. Always ride forward to refresh your horse's impulsion.

slowly shifts more weight to the haunches, his head and neck assume a progressively higher carriage. As this happens, he must start to use the muscles of his upper neck to maintain the tension in his SSL. The horse can maintain tension in the SSL with his head raised but only to a certain point. This is referred to as "relative elevation" (Illustration 1, p. 64).

If the rider raises the head/neck position too high, he causes the SSL to lose tension, and the back will drop. This is called "absolute elevation" (Illustration 4). In absolute elevation, the horse's COM is shifted toward the rear but his back has dropped. This causes him to brace his long back muscles to try to support the rider's weight. When the long back muscles are braced, the horse cannot move in a biomechanically correct manner. Over time, this can lead to poor performance and injury.



3. Stretching



4. Absolute elevation

Illustrations by Sandy Rabinowitz

Looking at the horse's back from the withers to the tail, the SSL is attached to the top of each vertebra and runs over the top of the lumbosacral joint (LSJ). The lumbosacral joint attaches the horse's pelvis to the spine. When he rotates the pelvis under and around the LSJ, the tops of the sacral vertebrae rotate down and back slightly. This creates a pull from the haunches that helps keep the SSL tensioned and the back raised. It is this pull on the SSL via the position of the haunches that helps to compensate for the lowering in the ligament tension that results from the raising of the head and neck.

Key Point 2: Biomechanically,

collection creates a set of competing influences that have to be kept in balance if the horse is to move efficiently.

Other Components of Collection

The horse's core, for our purposes, is composed of the abdominal muscles and the muscles that raise the base of the neck. The abdominal muscles do help to lift the horse's back but only during the push from the hind legs at trot and canter. The widespread belief that the horse's abdominal muscles carry the rider is incorrect. It is the tensioned SSL that carries and supports the rider's weight (*Tug of War*, Heuschmann).

Of great importance in collection is the position of the horse's basal joint. This joint connects the vertebrae of the neck (cervical vertebrae) to the first thoracic vertebrae. Thoracic vertebrae 2 to 10 are the ones that form the base of the withers. When the horse raises his basal joint and lifts his withers, he causes his neck to telescope forward slightly. This causes the SSL to receive both a slight pull forward from the poll and a push up from the withers, which helps him compensate for the drop in tension that occurs in the SSL as he raises his neck.

Key Point 3: The development of true collection is dependent on the horse's ability to carry weight on his hindquarters while maintaining a flexed topline. Raised withers help to maintain topline flexion.

In summary, the classical training methods that develop correct collection honor the biomechanics of the horse.

Steve Crowell

Anne Crowell has an engineering degree from California State University. Currently, she is a graduate student in applied physics at George Mason University and a member of the American Society of Biomechanics. A student of Charles de Kunffy introduced her to dressage, and she later became a saddle fitter trained by the UK Society of Master Saddlers. She lives with her family in Northern Virginia.