The Mysteries of Collection

Just how does a horse collect his gait? The McPhail Center aimed to find out.

BY HILARY M. CLAYTON, BVMS, PHD, MRCVS

One of the ongoing areas of research in the McPhail Equine Performance Center is the mechanics of riding technique and the rider's effects on the way the horse moves and carries himself.

Trainers and clinicians who visit the center are encouraged to take part in these studies. Recently, we were fortunate to have a well-trained stallion, Ritmeister, donated to the program (see "Meet the Participants," page 54). In his new role as a research horse, Ritmeister's first assignment involved a study of kinematics (movement) and ground-reaction forces in the collected trot.

Well-known Pennsylvania-based trainer Paul Belasik agreed to donate an afternoon of his time to ride Ritmeister in this study. He was interested in learning more about the effects of collection on the horse's carriage and weight distribution.

A study was designed to evaluate the effects of collection on ground-reaction forces, as measured by the force platform. These forces indicate how much weight each limb is carrying and how much propulsion it is providing. At the same time, a motion-analysis system would track reflective markers attached to Ritmeister's skin to measure the angulation of his trunk, neck, and head as the trot became more collected.

Researchers prepared Ritmeister for the study by sticking the reflective markers to the locations shown in Figure 1 at right. Two markers on the front of his face would indicate whether his head was in front of or behind the vertical. Three markers on his neck, one at the poll, one above the third vertebra, and one in front of his withers would describe the shape and elevation of his neck. A marker at the back of the saddle would track the height and position of his croup.

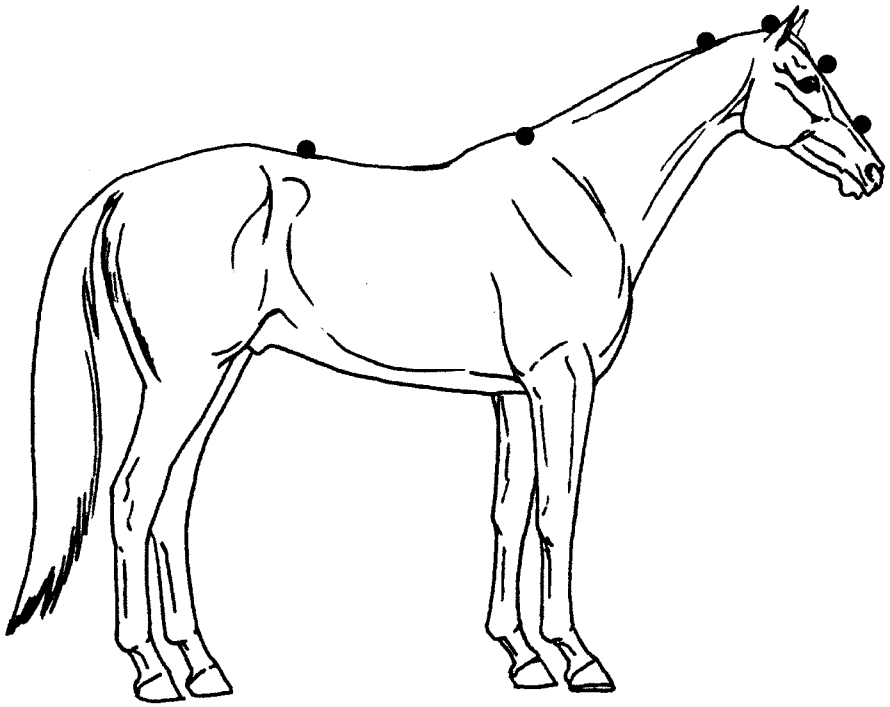
Paul and Ritmeister got to know each other during their warm-up in the Gaide Arena, adjacent to the runway used for data collection. Paul gradually asked for more engagement and collection. When he felt that Ritmeister was adequately collected, he began riding along the rubber-covered runway and over the force platform. As he rode, the motion-analysis system automatically tracked the reflective markers. The force platform recorded the forces of the horse's hooves against the ground, and sensors in the reins monitored the tension in the reins.

The trials deemed usable for analysis were those in which Ritmeister stepped on the force platform with one hoof at a time. In most of the good trials, he would tread on the force platform with a front hoof followed by the hind hoof on the same side, with a small interval (between the time the front hoof left the force plate and the hind hoof contacted the plate) representing the airborne phase of the trot.

After we had collected data from several trials, Paul allowed Ritmeister to fall onto his forehand for the next set of data collection. Several trials were again recorded.

Motion Analysis

In analyzing the data, we first compared the kinematics of the collected trot to the



COURTESY OF THE McPHAIL EQUINE PERFORMANCE CENTER DATA COLLECTION

Figure 1. Black circles indicate locations of markers on horse.

trot on the forehand. We were particularly interested in the movements of the horse's back, the sinking of his croup, the elevation of his forehand, and the positions of his head and neck.

Vertical motion. As one might expect, Ritmeister was shorter from croup to nose in the collected trot than in the trot on the forehand. Movements of the marker behind the saddle showed that his croup was lower in the stance (ground-contacting) phase and higher in the airborne phase in the collected trot (see Figure 2 at right). His croup had a larger range of vertical movement in the collected trot, the result of a combination of "sitting" more by compressing the joints of his hind limbs when the diagonal limb pairs were on the ground, and then projecting his body higher in the airborne phase. In other words, collection made his trot more bouncy.

Like his croup, Ritmeister's forehand and neck also rose during the airborne phases and descended during the diagonal stance phases. In contrast to the movements of his trunk, however, the movements of his forehand were reduced as the trot became more collected because there was less sinking in the stance phase.

To sum up, the horse's shoulders and neck remained more elevated during the stance phase of the collected trot, while his haunches lowered due to compression of the hind limbs.

Body angles. As a result of this combination of lowering the haunches and elevating the shoulders during the stance phase, Ritmeister showed more elevation of the forehand in the collected trot than in the trot on the forehand, especially in the early part of the stance phase. His neck also was more elevated in the collected trot, with his poll the highest part of his neck and the front of his nose about 10 degrees in front of the vertical.

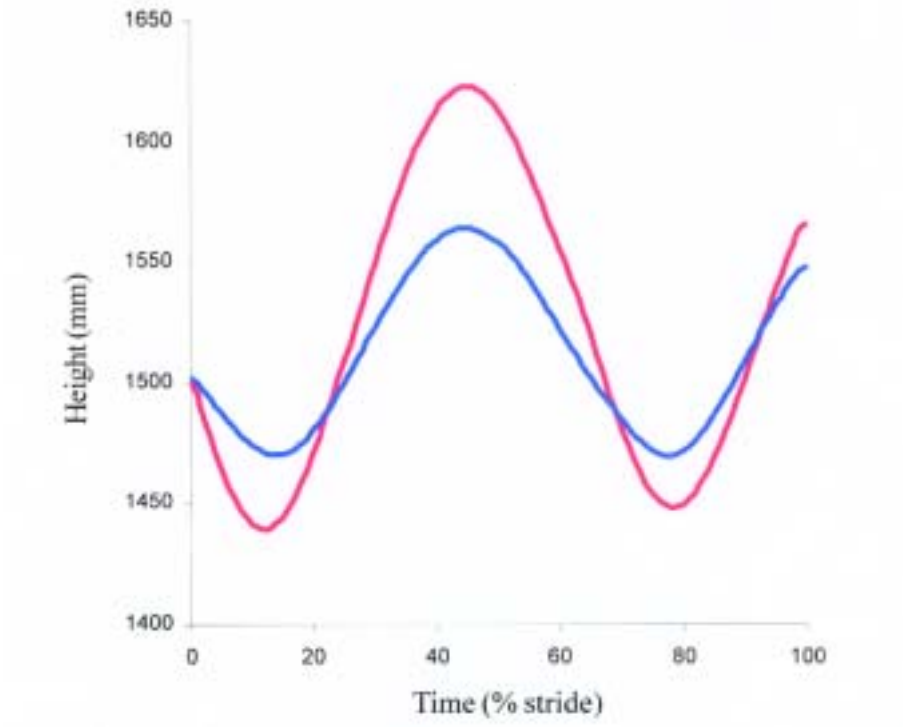


Figure 2. Graph showing vertical excursions of the croup during collected trot (red line) and trot on the forehand (blue line).

In contrast, when Ritmeister trotted on his forehand, his neck was less elevated, his third vertebra was higher than his poll, and the front of his face was behind the vertical by about 10 degrees.

Weight-Bearing and Propulsion

The force plate records vertical force, which is the amount of weight carried by each limb and its role in providing "lift" to raise the horse into the airborne phase. In general, horses' front limbs bear more weight than their hind limbs because their center of gravity is located a little closer to the forehand.

As we expected, the results of our study showed that the hind limbs have a greater vertical force in the collected trot, indicating that they carry more weight during collection.

This increased weight-bearing by the hind limbs was apparent throughout the stance phase. In the graph on the next page, which depicts the vertical force, the red line (the collected trot) is higher than the blue line (the trot on the forehand).

One might expect the front limbs to show a corresponding reduction in vertical force, but our findings showed otherwise. In fact, the vertical force on the front limbs was actually *higher* during the first half of the stance phase in the collected trot; and the peak vertical force in the front limbs was obviously higher in collected trot than in the trot on the forehand (see Figure 3 next page).

The force plate also records the longitudinal force, which controls the horse's speed and is responsible for acceleration (propulsion) and deceleration (braking). Typically, the value of the longitudinal force is negative early in the stance phase and positive later in the stance phase in all limbs, as shown by the blue line in the graphs of the longitudinal force. During the negative phase, the longitudinal force acts to brake the forward motion. During the positive phase, it provides forward propulsion. Horses' natural tendency is for the front limbs to provide higher braking forces while the hind limbs pro-

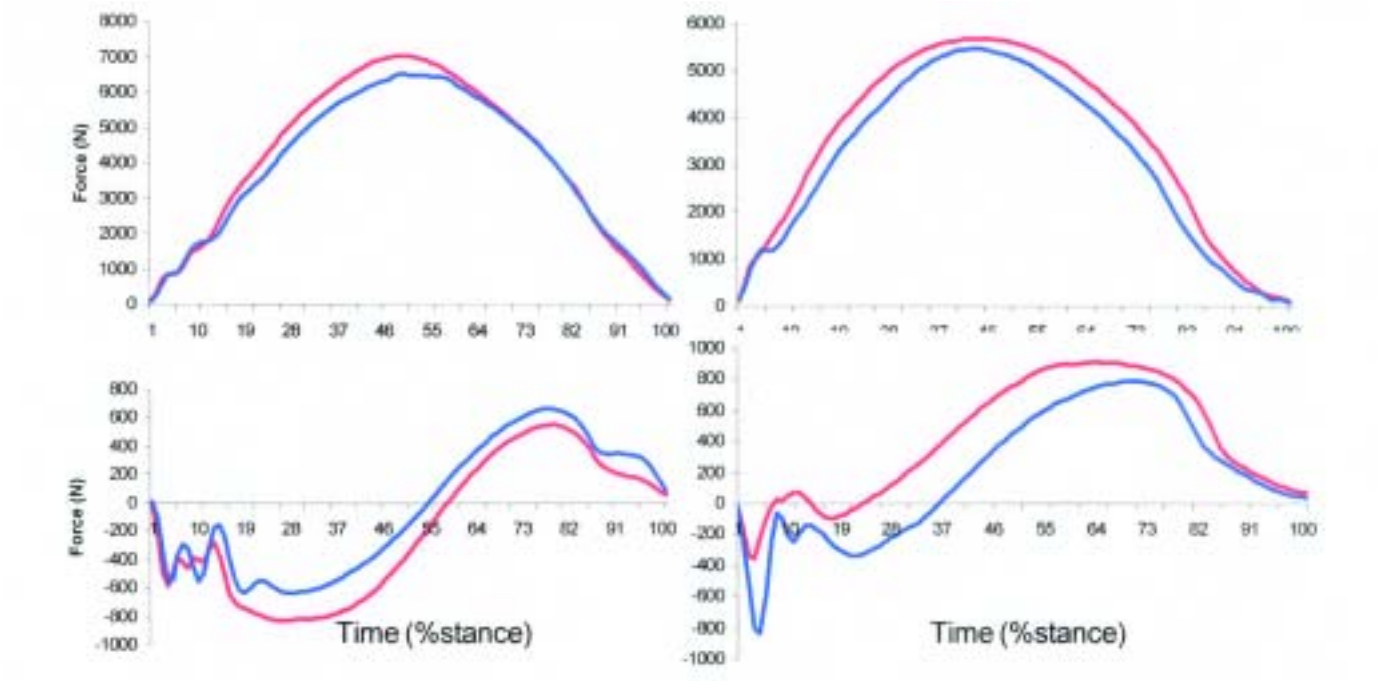


Figure 3. Graphs showing vertical forces (top) and longitudinal forces (above) for the front limbs (left) and the hind limbs (right). Collected trot is in red, and trot on the forehand in blue.

vide more propulsion, as shown by the longitudinal-force graphs of Ritmeister's trot on the forehand.

Our experiment showed clear differences in the longitudinal forces between Ritmeister's collected trot and his trot on the forehand. His front limbs showed a large increase in braking (negative force) as well as a reduction in propulsion (positive force) in the collected trot, which is represented on the graphs by the red line. His hind limbs showed the opposite effect: They provided virtually no braking and a large propulsive force (Figure 3).

The changes in the forces can be interpreted in light of the alterations in the motion patterns. Early in the stance phase, Ritmeister's front limbs showed increases in both vertical and braking forces, which had the effect of pushing his shoulders up and back. So, instead of rolling over his forehand, his shoulders and withers were actively elevated by the action of his front limbs. Furthermore, the height of his withers and the angulation of his body axis did not change simply because his haunches lowered; they changed in part because he actively elevated his shoulders.

The expected kinematic changes that took place during the collected trot confirmed our subjective impressions of the effects of collection. The ground-reaction forces, however, are not visible to the observer. The horse can change the way his hooves push against the ground by altering the muscle tension without causing any change to the kinematics. The vertical and longitudinal forces indicate the horse's degree of balance and the functional responsibilities of his front and hind limbs. This study shows that collection is not achieved simply by lowering the haunches relative to the forehand; it also requires active elevation of the forehand through the front limbs' pushing harder against the ground.

Rein Tension

When Paul rode Ritmeister for our study, we fitted him with rein-tension sensors in addition to recording kinematic and force data. As with the other riders who have participated in this field of study, the rein tension was recorded as a series of spikes that occurred in rhythm with the horse's limb movements. In the trot, there were two spikes per stride, which corresponded with the gait's diagonal rhythm.

MEET THE PARTICIPANTS

Ritmeister, a black Westphalian stallion and a former ABIC/USDF Intermediate I regional champion, was donated to the McPhail research program by Tamara Y. Gerber. He is now being used in dressage-performance research and as a breeding stallion. All proceeds from breedings will support McPhail Center research efforts. For information about the breeding program, contact Dr. Carla Carleton at (517) 353-3267.

FEI-level rider and trainer **Paul Belasik** is the author of *Riding Towards the Light, Exploring Dressage Technique, The Songs of Horses,* and *Dressage for the 21st Century.* He is based at his Pennsylvania Riding Academy at Moonlight Park, Kennett Square, PA.

When Paul assessed the contact as being correct, the tension spikes (the greatest amount of tension measured, not a constant) peaked at around five pounds. Between spikes, the tension decreased to around one pound, and the mean value throughout the stride was around three pounds. These measurements are in the same range as we have found in other trainers riding different horses.

We are grateful to Paul Belasik for donating his time and expertise in performing this study. We hope to have an opportunity to continue these studies by giving other experienced trainers an opportunity to take part in the future. ▲

Hilary Clayton, BVMS, PhD, MRCVS, is a world-renowned expert on equine biomechanics and conditioning. Since 1997, she has held the Mary Anne McPhail Dressage Chair in Equine Sports Medicine at Michigan State University's College of Veterinary Medicine, East Lansing. The position focuses on dressage- and sport-horse-focused research. Dr. Clayton contributes a quarterly report to USDF Connection *on her team's research efforts and findings, which she hopes will help dressage and sport-horse breeders, owners, riders, trainers, and caretakers to enjoy longer and more productive careers with their animals.*

CLINIC FROM PAGE 42

You may have been in too great a hurry to move through the levels. It is definitely more exciting to do flying changes than simple changes. Even more exciting is when one can wear a tailcoat rather than a short jacket! There is that thinking that "We did Second Level last year, so we have to do Third Level this year." However, this progression is possible only if your horse's basics have been developed correctly from the beginning.

The difference between a horse whose training has been rushed and one that has been developed slowly and correctly is much like the difference between fast food and gourmet cuisine. The differences are obvious, and the latter reflects a well-prepared and carefully developed recipe built on basics. ▲

Next month: Lilo Fore continues her discussion of training for Third Level.

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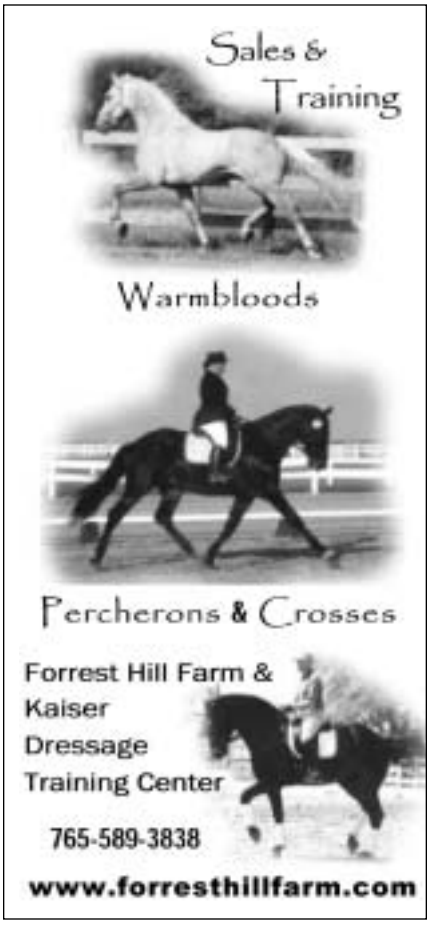
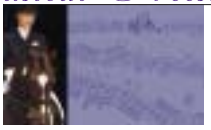


Musical Freestyle



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