

Chancellor Honors Program
University of Tennessee
F101 Melrose Hall
Knoxville, TN 37966

THE EFFECT OF INCREASING A RIDER'S WEIGHT ON A HORSE'S STRIDE

Kathleen Benton
Senior Honors Project
University of Tennessee
College of Agriculture
Knoxville, TN

Faculty Advisor: Dr. Cheryl J. Kojima
Research Assistant: Paul Roberson

ABSTRACT

This study examined the effect of a rider's weight on the horse's motion. Stride characteristics of three middle-age quarter horse geldings were examined under normal conditions and with 20 lbs then 40 lbs of additional weight (total 170.7 lbs $\pm$ 6 lbs). Earlier studies revealed that under the calculated force of a rider, an anatomical model showed increased stiffness in 2/3 of the horse's back (Peham and Schobesberger, 2004). Under similar weight in a different study, the back showed elongation, or a "hollowing" effect, when a rider was added (de Cocq *et al*, 2004). In this study, each horse was videotaped at the working trot with just a rider then with the rider fitted with a vest holding 20 lbs and finally 40 lbs. Duration of swing phase, suspension, stance phase overall stride was measured. All three horses showed similar changes under the additional 20 lbs, elongating the stance phase and shortening the suspension phase at the working trot. However, when 40 lbs was added to the rider, two of three horses followed the same trend as 20 lbs, but one horse's stride characteristics were closer to that of the control group. The results show that the horse's gait responds to the weight of the rider. Further study is needed to determine the exact effect on the horse's back and speculate the long term implications from those changes in gait.

Key Words:

Rider's weight, Stride time, Suspension phase, Stance phase, Swing phase, Equine spine, Movement along spine, Navicular changes, Extension, Motion of limbs, Gait

INTRODUCTION

Adding weight to a horse's back changes the curvature of the spine as well as the motion of the front and hind legs. Over time, such changes in the horse's natural motion can cause back pain of clinical concern (Licka *et al*, 2001). To determine the long term effect of carrying the load of a rider, the changes in the horse's movement while under saddle need to be evaluated.

During unhindered movement, the lateral motion of the horse's back follows sinusoidal pattern, shown in two separate studies (Audigie *et al*, 1999 and Licka *et al*, 2001). The earlier study observed this vertical pattern over multiple trials, indicating consistency in motion (Audigie *et al*, 1999). The findings were supported by the latter study led by Licka also tracked the lateral and transverse motion of the back. Their data

about lateral motion supported Audigie's. When measuring transverse motion, the thoracic spine (marker at T5) shifted toward the front leg in stance phase indicating that the forelimb is the primary support for the horse's trunk while in motion (Licka *et al*, 2001).

Adding the rider's weight caused lateral stiffness in the thoracic region of the horse's back (Peham and Schobesberger, 2004). The addition of the saddle and rider (average body mass was 68 kg) caused increased vertical force to the horse's back and legs: walk 3.83 N/kg, trot 5.18 N/kg and gallop 5.60 N/kg. Further investigation of the effect on the spinal column was derived through the use of an anatomical model that represented the thoracolumbar spine. Under the pressure of a rider, approximately 2/3 of the model showed increased lateral stiffness.

Due to the horse's muscular attachment of the shoulder and hip to the vertebra, the contraction and extension of the back are directly influenced by the swing of the limbs. Conversely, if the back is abnormally shortened, or "hollowed" (shows greater downward curvature), the movement of the limbs is affected as well (de Cocq *et al*, 2004). Study on a treadmill, analyzing the spine's range of motion at L3 and L5 revealed that 75 kg of weight added to a saddle induces extension throughout the back. Limb kinematics, on the other hand, remained the same regardless of the additional 75 kg.

METHODS AND MATERIALS

Horses, Riders and Saddles

Three middle-aged Quarter Horse geldings were videotaped in this experiment. Horses were sound and ridden daily; however, two had been previously diagnosed with the first stages of navicular disease. During the experiment, horses were ridden in the

saddle and bridle to which they were accustomed. Also, the riding arena was one in which they were ridden daily.

All three horses were of similar body type and bone composition. The group's mean age was 17.3 years $\pm$ 2.7 years, and their average height was 62.4 inches $\pm$.3 inches. The horses were accustomed to daily exercise with intermediate riders of varying weights.

Each horse carried the same rider throughout the experiment although the rider for horse one was different than that of horses two and three. The riders' mean weight was 129 lb $\pm$ 6 lbs. Both riders were experienced and trained to perform at high levels.

Data collection

Horses were warmed up prior to taping. They were then videotaped at the working trot. The horses were ridden first at no additional weight. Weight was added in increments of 20 lbs to the rider for an additional two tests. No less than three trials with each weight were recorded.

The primary camera used was a Canon ZR10 (film speed of 30 frames per second, maximum resolution of 460,000 pixels, effective resolution of 290,000 pixels). A Sony Mavica MVC-CD500 was used as a back up camera (film speed of 16 frames per second, resolution of 307,000 pixels).

To add weight to the rider, a snugly fitting Xvest (weight 1.7 lbs with no weights inserted; Xtreme Worldwide Athletic Equipment; Katy, TX) was added to the rider. By using the vest, weight could be added to the rider's center of gravity in a natural pattern of weight gain. Twenty 1 lb cylindrical weights were added (weight with rider was 150.7

lbs $\pm$ 6 lbs). The horses were ridden again at the same paces. Another 20 lbs was added to the vest, increasing the total weight to 170.7 lbs $\pm$ 6 lbs for the final round of trials.

Data analysis

The stance phase was defined from heel strike to toe off of a diagonal pair. Suspension phase was the stage in which all four feet were non-weight bearing. Both were measured from the video tape.

The swing phase incorporated the time from toe off to heel strike of a diagonal pair. Two suspension phases were included in the swing phase, one as the diagonal pair left the ground and one as the opposite diagonal pair left the ground. Total stride was the time from toe off to the following toe off of a diagonal pair. The duration of swing and stride were calculated from the data already collected about stance and suspension.

A mixed model analysis was used to generate least square means. Fixed effects were weight and trial; horse was considered a random effect. Dependent variables included stance, suspension, swing, swing/ stance ratio and total stride time.

Note: ("Horse" was a significant factor for all variables measured ($p > 0.0001$). There was no effect of trial on any variable so it was removed from the model. All data reported are effects of weight.)

RESULTS

Analysis revealed that horses adjusted their stride under the weight added to the rider. While the total stride time remained similar, the suspension phase shortened causing an elongated stance phase. No significant difference was noticed in the swing time, even though the suspension phase (a component of the swing time) changed.

Weight added to the rider increased the time when the horse was in stance phase ($p < 0.0001$; see figure 1).

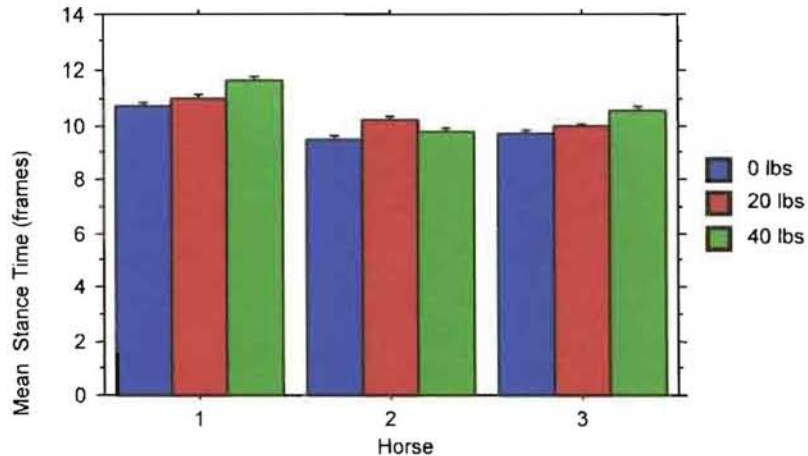


Figure 1: Effect of Weight on Stance Phase Time
(Effect: Horse * Weight; Error Bars: ± 1 Standard Error)

With 20 lbs, all three horses left their supporting limbs on the ground longer than the control group. When 40 lbs was introduced, two of three horses continued the trend, elongating their stance phase even more from 20 lbs to 40 lbs than from control to 20 lbs. To accommodate the extra weight, horses left their supporting limbs in contact with the ground.

In contrast to elongating the stance phase, increasing weight shortened the suspension phases ($p < 0.0001$; see figure 2).

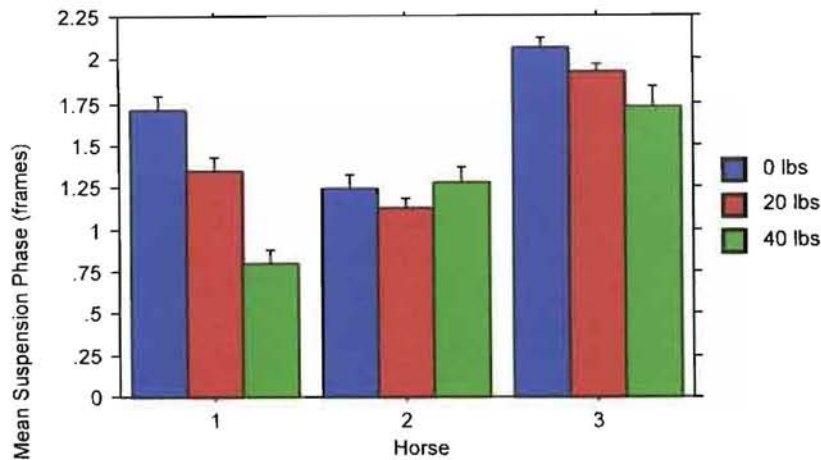


Figure 2: Effect of Weight on Suspension Phase
(Effect: Horse * Weight; Error Bars: ± 1 Standard Error)

The decreased time of the suspension phase coincides with the added length to the stance phase.

Weight did not significantly affect swing phase (see fig. 3).

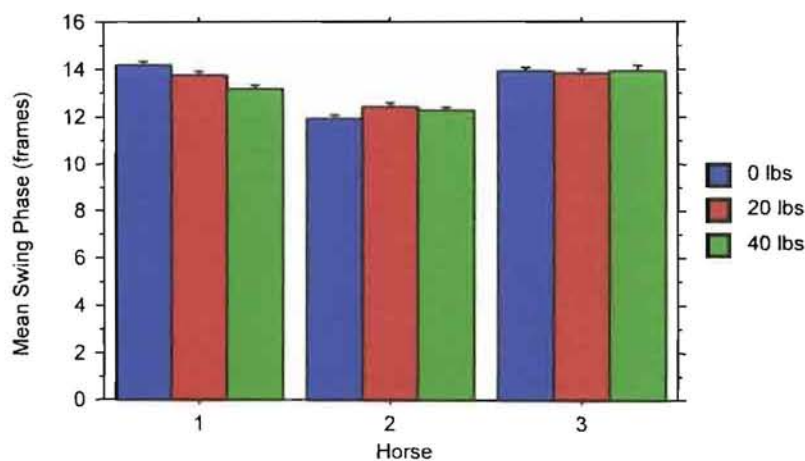


Figure 3: Effect of Weight on Swing Phase
(Effect: Horse * Weight; Error Bars: ± 1 Standard Error)

The consistent swing phase supports the explanation that the increase in stance phase is made up primarily by the shortening of the suspension phase. In two horses, swing phase was shortened when weight increase from 20 lbs to 40 lbs.

Weight increased total stride time ($p = 0.0033$; see fig. 4). This effect was more clearly noted at 20 lbs; horses variably to the 40 lb weight.

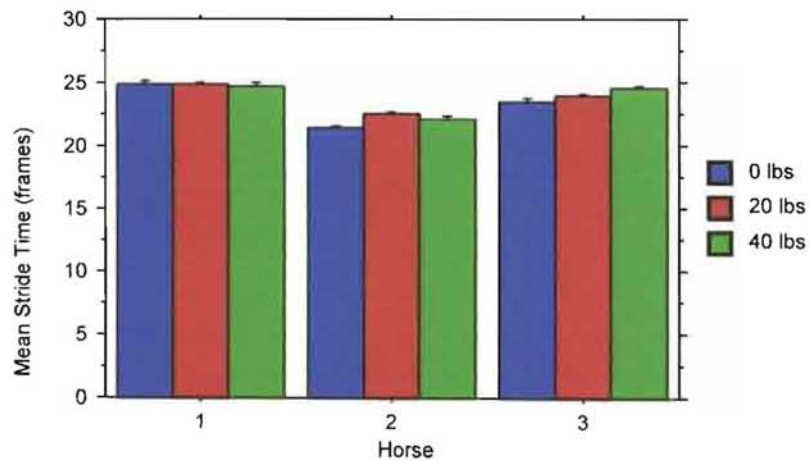


Figure 4: Effect of Weight on Total Stride Time
(Effect: Horse * Weight; Error Bars: ± 1 Standard Error)

Finally, comparing swing to stance time, the ratio decreased as the stance time shortened ($p < 0.0001$; see fig. 5).

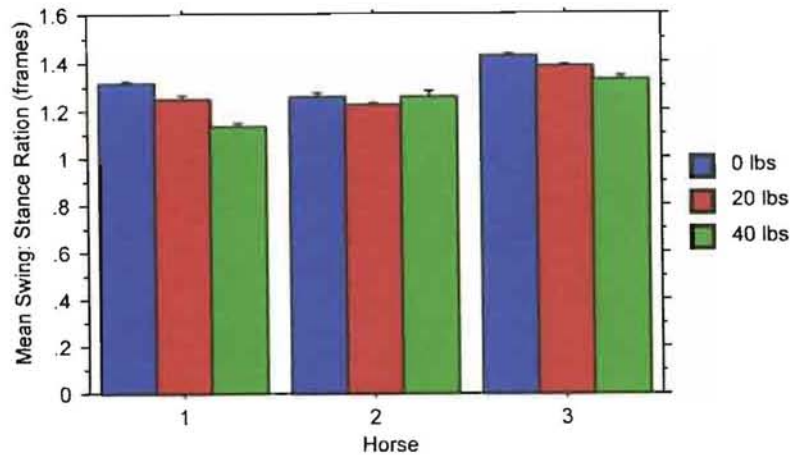


Figure 5: Effect of Weight on Swing: Stance Ratio
(Effect: Horse * Weight; Error Bars: ± 1 Standard Error)

The decrease in swing: stance was mainly due to the effect of weight on duration of stance phase.

DISCUSSION

The study showed that the rider's weight affects the horse's stride by lengthening the stance or supportive phase and shortening the suspension phase at the working trot. The changes seen when 20 lbs was added were more consistent from horse to horse than the addition of 40 lbs. The numbers one and three horses both showed signs of lameness under 40 lbs. On the other hand, horse number two tracked more closely to his natural gait with 40 lbs. He compensated for the additional weight by tightening his abdominal muscles and rounding his back. The other two horses reacted to the added weight by hollowing their backs more. Previously diagnosed navicular changes in these horses

could cause them additional pain and prevent them from engaging their hindquarters, causing the results to vary.

Using the same rider for each trial allowed manipulation of weight without variability in riding style. If different riders of different weights had been used the data could have been skewed by different techniques employed by the riders. Instead, the weighted vest worn by a rider eliminates variability from riding styles.

The horse's head and neck positions posed potential inaccuracy. In a study led by Rhodin, movement along the horse's back was evaluated while the head was held in three different positions: free, lowered so that the top line was level with withers and raised so that the bridge of the nose was vertical (2005). Data showed that while changing the head position caused a decrease of back movement in the walk and canter, it had little effect, if any, on the trot. Therefore, this study, performed at the trot, was uninfluenced by changes in the horses' head and neck positions.

Use of a saddle was another source of potential inaccuracy. When improperly fitted, saddles are one of the leading causes of back pain in horses (de Cocq et al, 2004). Two studies, one by de Cocq et al and another by Fruehwirth et al (2004), showed that carrying a saddle had relatively little effect on the back's motion compared to a saddle with rider. Similarly, tightening the girth around the withers and sternum had no measurable effect. Therefore, the saddles were not considered a significant variable.

The study would be more complete if stride length and velocity were evaluated. These variables would indicate whether the horses were changing the pace of the stride as well as the rhythm to accommodate added weight. Time constraints did not permit

including these factors in this report; however, needed study is being performed to evaluate those factors.

To make data more accurate, a larger sample size should be used. By increasing the number of horses, researchers could study whether the addition of 20 lbs consistently follows the trend seen in this study. Also, studying a variety of animals carrying an additional 40 lbs, particularly including those proven sound, would give more definitive information than this study can.

During evaluation, researchers observed changes in stride that could not be quantified in this study. Under normal conditions, the horses' front feet hit the ground before the hind feet at the heel strike; during toe off, the hind feet left the ground first. This indicates that the horse has transferred his weight to the forehand and is not engaging his hind end as desired. When 20 lbs was added to the rider, the front and hind feet moved in unison. The horses shifted their weight to their hind legs, using their haunches to propel them forward. Forty pounds caused the animals to revert to the unsymmetrical gait. To substantiate this trend, markers need to be placed on the horses' legs, recording more precise variation in limb motion. Also a camera that recorded at higher speed and with better resolution would give a clearer depiction of how the horse's movement is changing.

If studying the spine and changes in gait mechanics were desired, a different approach would be required. Instead of measuring the effect on the limbs and inferring changes in the spine, the actual movement of the spine would be a more accurate indication of changes. Three-dimensional markers should be placed on the horse along

the back and at the joints of the hind leg. Using 3D imaging would allow a more correct analysis of the rider's effect on the extension and flexion of the horse's back.

This study was a good pilot, showing that significant changes are seen in the horse's gait when the rider's weight increases. Research also revealed that this subject is more complex than first realized. More study employing more advanced technology on a larger sample would be beneficial in further understanding how horses compensate for additional weight.

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