Biomechanics Applications to Performance Horses

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Movement of the horse is a critical consideration for most horse owners in any discipline. The value of the horse is usually directly tied to how well it moves, and horses are often selected primarily on this criterion. Lameness evaluations are typically based on evaluation of movement, and much money is spent on products or techniques that claim to improve equine performance. This leaves many horse owners wondering "does this really work?" when trying a new product or technique. Applied research in equine biomechanics, or the study of horse movement, is a way to investigate some of these questions.

Understanding Biomechanics

Two types of analysis can be used to study the biomechanics of the horse: kinematics, or examining movement through analysis of video, and kinetics, or examining movement through forces exerted by a limb (e.g., on a forceplate). For purposes of this talk, we will be referring only to kinematic analysis.

Use of high speed video to define and quantify aspects of the horse gait has been a useful tool for exploration into topics such as gait quality, lameness, and shoeing and training effects. Video frames can be isolated, and measurements can be made spatially (examining variables such as step length, maximum hoof height, minimum and maximum angles of joints, etc.) and temporally (quantifying swing time and stance time, or the time the limb travels through the air or stays on the ground).

While the study of equine biomechanics is widely varied, this article will discuss some of the recent findings in our applied biomechanics research at UGA and how these pertain to performance horses.

Using Biomechanics to Examine the Effectiveness of Supplements

Supplements are often given to improve performance of the horse. Improvements can be manifested as a reduction in lameness or an improvement in gait quality. Kinematic research has been used to examine potential benefits of joint supplements. Main ways improvement can be seen is through increased range of motion of the joints, increased stride length, or an improvement of swing:stance ratio (longer time in the swing phase). Previous research has documented an improvement in carpal flexion scores in induced carpal arthrosis when horses were injected intramuscularly with Adequan as compared to glucosamine or chondroitin sulfate. Additionally, research examining effects of oral supplementation of glucosamine and chondroitin have shown positive response in joint range of motion in veteran horses after 8 weeks of supplementation. In separate studies, research from our lab examined the effects of a prescribed Adequan program as well as oral glucoasamine sulfate on gait quality in serviceably sound horses. Results indicate that the main improvements after supplementation with either of these products can be seen in the fetlock and hock joints. Significant improvements were seen in fetlock dorsiflexion, elbow flexion, and hock flex-

ion following treatment with Adequan IM. A separate study examining oral glucosamine sulfate supplementation also showed modest increases in fetlock dorsiflexion and hock flexion after 90 days supplementation. Stride length, as well as swing and stance times, were not affected by either supplement.

Biomechanics as a Tool for Farrier Topics

Studying kinematic changes in response to shoeing practices can be useful to determine realistic expectations based on differences in shoe weight and placement. Previous research has documented changes in biomechanics due to shoe weight, with increased weight causing higher carpal and hoof heights and increased flexion of the carpus (more "action" to the stride). Recent research in our lab compared the two most common shoe types of steel and aluminum to determine differences in biomechanics between the two. Studies where horses were fitted with steel and aluminum shoes in random order demonstrated that the weight difference between aluminum and steel shoes is enough to cause about a 3° difference in carpal angle along with a lower peak hoof height. No differences in stride length were observed.

Research has also examined the effects of shoe shape on biomechanics, particularly as pertaining to breakover of the hoof. Improving ease or speed of breakover is a common practice encouraged by some veterinarians and farriers to potentially treat conditions such as navicular disease caused by pressure on the deep digital flexor tendon, and prevent future lower limb lameness in horses. Previous research has compared rocker toed, square toed, rolled toed, and flat shoes and shown very few kinematic differences, although rolled toed shoes have been shown to improve ease of breakover. When examining the effects of trimming on hoof breakover, it has been shown that acute hoof angulation prolongs hoof breakover and

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increases strain on the navicular ligaments. Recent research into hoof breakover location has demonstrated that moving the point of breakover caudally (away from the toe) by 0.5" as compared to breakover occurring at the perimeter of the hoof resulted in greater retraction of the front legs (associated with higher gait quality or reduced lameness) as well as higher minimum fetlock heights during the stance phase (possibly reducing strain on the deep digital flexor tendon), but movement of more than 0.5" was associated with some decreases in gait quality.

Biomechanics and Riding/Training

The study of equine biomechanics can be of particular importance to those interested in understanding the natural and trained gaits of the horse, improving performance and long term soundness, and examining the effects of a rider. Recent research examining effects of added weight on biomechanics of the horse has demonstrated that a saddle plus 100 lbs of added weight is enough to cause significant increase in dorsiflexion of the front fetlock joints (indicative of more strain on lower limb tendons) as compared to unweighted horses, implying that weight of rider should be proportional to size of horse for long term soundness of the lower limb. Weight distribution was compared to determine how symmetrically loaded weight compared to asymmetrically loaded weight affects the gait of the horse. Asymmetrically loaded weight that mimicked a 10° lean of a 100 lb rider or a 5° lean of a 200 lb rider caused slight adaptations in the gait of the horse at the trot, but modifications were not nearly as significant as those seen by adding weight to an unloaded horse. An interesting finding of this study pertains to motor laterality or "sidedness" of the horse. Research on laterality in foals and young horses has indicated that as horses age, regardless of handling, they exhibit an increasing motor bias towards the right side. This right side dominance actually causes the horse to favor circling to the left due to a greater thrust from the right hind leg and a corresponding increase in the supporting hind limb engagement (left hind limb being brought further under the body) to allow the horse to bend more readily on a circle to the left. Interestingly, horses in the study mentioned above exhibited increased left hind limb stride length as well as more dorsiflexion of the right hind limb, potentially supporting the notion of a natural "sidedness" or motor laterality of the horse associated with an increased ability to bend or circle left.

Conclusions

Applied research in equine biomechanics is a wide field that has allowed for examination of topics of particular interest to performance horses. Research into joint supplements has demonstrated some improvements in joint range of motion in response to certain studied supplements. Shoe material has also been examined, with aluminum shoes showing modest changes in carpal action and hoof height as compared to steel, but with no change in stride length. Research into shoe placement has shown that shortening the point of breakover slightly may result in some improvement of gait quality, but that extreme movement of breakover away from the toe may negatively impact gait quality. The influence of rider weight as well as weight distribution has also been examined, revealing that uneven distribution of weight has some influence on stride properties but that the addition of weight, whether evenly or unevenly distributed, has more of an effect on the biomechanics of the horse, particularly on lower limb kinematics. Finally, research has supported the notion that most horses maybe side dominant, naturally being able to bend and circle left easier. ■