Energy Absorption Capacity of Commercial Equine Support Boots

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Conclusion Portion

Our testing protocol was similar though not identical to the protocol developed by Crawford et al. (3) at the University of Wisconsin-Madison in 1989. Dr. Crawford compressed his experimental limbs 7.65 cm at a rate of 3.85 cm/s, which approached the maximum reliable continuous cycling stroke rate available on his equipment. Our maximum continuous cycling rate was 2.1 cm/s with a deflection of 6.75 cm, which was the limit of our equipment.

Our primary objectives were to measure and compare energy absorbed by limbs when different versions of commercial equine sports medicine boots were applied and relate that absorption to previously gathered data on the prototype of the commercial product. Admittedly, our current maximum loading rate, 2.1 cm/s, as well as the original experimental loading rate, 3.8 cm/s, was lower than that expected with physiological loading with normal equine locomotion. The previous and current experimental protocol used quasi-static testing that is characterized by low loading rates that are useful for a first approximation. The current data, and that previously obtained at University of Wisconsin-Madison, have inherit limitations of in vitro data, and their extrapolation to in vivo conditions must be approached with caution. Measuring the effects of commercial equine sports boots on the kinematics and kinetics of the distal limbs and fetlocks in live horses working at speed are necessary to validate the use of sports medicine boots as techniques to prevent and rehabilitate injuries.

The results of our testing at Oklahoma State University mirror those at University of Wisconsin-Madison. Dr. W.H. Crawford, in an unpublished report titled "Biomechanical Evaluation of Prototype Sport Boots and Commercial Sports Medicine Boots" recorded the mean bandage effect of new and used commercial Sports Medicine Boot (SMB I) as 21.25% and 24.54%, respectively. In the current experiments conducted at Oklahoma State University, the mean bandage for the SMB I was 20.4%. The fact that the mean bandage effects of SMB I (measured at two different institutions nearly a decade apart on different legs and different equipment) were within a single percentage point supports the validity of the testing procedures used at both institutions. A direct comparison between a used SMB I and a used SMB II was not possible, as products were tested at different times. However, we also measured an increase in the mean bandage effect of new and used SMB II as 23.4% and 26.4%, respectively.

Pooling the EAC data for the tested commercial support boots, the values of the bandage effect for individual limbs ranged from 4.7-45%. The relative ranking of the energy absorption capacity of the different commercial support boots varied with the individual leg examined. For example, the mean bandage effect for one leg was highest for SMB I (17.6%) and lowest for SMB II (10.7%); the mean bandage effect for leg five was highest for used SMB II (45%) and lowest for SMB I (31.7%).

This variability in effectiveness of a particular support boot in a single isolated leg underscores the necessity of using multiple legs to assess the energy absorption capacity of commercial equine support boots. Such variability could reflect a real difference between isolated legs, a failure to standardize the application of the boots, measurement errors inherent in the use of the material testing machine, or combination of all these factors. All Boots were applied by the same person using the same technique and tension. The force transducers for the material testing machine were calibrated with a dead weight at the beginning of each day's test and confirmed at the end of the day. Whether the variability reflects a real difference between isolated legs of simply a combination of experimental factors contributing to the experienced variation around an experimentally derived mean is unknown. Obviously, using the results from a single isolated limb to rank the energy absorption capacity of various equine support boots would be misleading and unscientific.

While mean values for various Sports Medicine Boots differed, the range of the values for individual legs was sufficiently great that there were no statistically differences. Never less, the mean energy absorption capacity of the Sports Medicine Boots tended to be increased with new generations of this product and with product use. Interestingly, the energy absorption capacity of these Sports Medicine Boots was not reduced (in fact slightly, not significantly, increased) by the use of the product for a period of 24 h in order to achieve "break in".

Musculoskeletal injuries are the major cause of attrition in racing Thoroughbreds (7) and likely other breeds of athletic horses. The use of support bandages is well integrated into the management of Thoroughbreds and Standardbred racehorses. This experiment and a previous one (4) support the concept that appropriate support bandages and boots may absorb some of the energy associated with high speed locomotion. Energy is stored in the elastic suspensory apparatus while the fetlock moves to its most distal and overextended position at the midstance position (5). After the limb moves beyond the midstance position, the release of stored energy assists the flexion of the distal limb at lift off and the elevation of the fetlock (1). Theoretically, the absorption of energy by the support bandages and boots while the fetlock overextends at midstance phase would decrease energy to be released during the swing phase. Determination of the significance of this effect awaits kinematic and kinetic findings of experiments using support bandages and boots on live horses working at speed. The commercial support boots increase the energy absorption capacity of isolated limbs by approximately 20-30%. Biomechanically, these support boots should reduce hyperextension of the fetlock in exercising horses and therefore reduce the strain in the structures that constitute the suspensory apparatus of the fetlock. To the best of our knowledge, only a single study (8) has been reported investigating the kinematic effects of a cohesive elastic bandage on a gait of exercising Thoroughbred racehorses. This study conducted on a high-speed treadmill, found that cohesive elastic bandages altered the gait kinematics in all horses. However, the alterations varied with the horses. In a high percentage of horses, the bandage resulted in a "more upright fetlock". Considerable difficulty exists in accurately identifying and then affixing kinematic markers to anatomical landmarks in bandaged limbs for locomotor studies. Nevertheless, experimentation with live horses moving at speed on the surfaces where horses compete will be necessary to confirm that equine support boots do, indeed, reduce fetlock hyperextension and subsequent flexor and suspensory strain.

References

1. Clayton H. Locomotion. In: Equine Sports Medicine. Jones WE (ed). Philadelphia: Lea & Febiger 1989; pp. 178.
2. Copeland RW, Bramlage LR. Surgery of the fetlock joint. In: Vet Clinic N Amer. Turner AS (ed). Philadelphia: WB Saunders 1983; 221-31.
3. Crawford WH, Vanderby R, Neirby D, Nordhiem, EV, Libbey CJ. An Equine Cadaver Limb Model to measure the Support Effect of Bandages Placed on the Lower Limb of the Horse. Vet Comp Orthop Traumatol 1989; 4: 177-82.
4. Crawford WH, Vanderby R, Neirby D, Nordheim, EV, Libbey CJ. The Energy Absorption Capacity of Equine Support Bandages. Part II: Comparison between bandages from different materials. Vet Comp Orthop Traumatol 1990; 1: 10-7.
5. Dimery NH, Alexander RMcN, Ker RF. Elastic extension of leg tendons in the locomotion of horse (Equus Caballus). J Zool 1986; 210: 415-25.

6. Harrison JC. Care and Training of the Pacer and Trotter. Columbus OH. The United States Trotting Association, 1969.
7. Jeffcott LB, Rossdate PD, Freestone J. An assessment of wastage in Thoroughbred racing from conception to 4 years of age. Equine Vet J 1982; 14: 185-98.
8. Kobluk CN, Martinez del campo L, Harvey-Fulton K, Libbey CJ, Walton J. A kinematic investigation of the effect of a cohesive bandage on the exercising Thoroughbred Racehorse. Proc AM Ass Pract 1988; 34: 135-48.
9. Landers TA. Professional Grooming and Care of the Racehorse Grand Prairie, TX: Equine Research, 1995.
10. Rooney JR. Biomechanics of Lameness in Horses. Baltimore: The Williams & Wilkins Company, 1969.