

EFFECT OF TWO BANDAGE PROTOCOLS ON EQUINE FETLOCK KINEMATICS

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EFFECT OF TWO BANDAGE PROTOCOLS ON EQUINE FETLOCK KINEMATICS

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VITA

Jennifer Shea Sanders, daughter of Richard Barre Sanders and Mary Susan (Nichols) Sanders, was born in Birmingham, Alabama on 6 October 1982. In 2001, she graduated with Honors from S.S. Murphy High School, Mobile, Alabama. She graduated from Auburn University on May 11, 2006. She received a Bachelor of Science in Biomedical Sciences and a Bachelor of Arts in Psychology. In the spring of 2006, Jenni met with Dr. Robert Gillette, Director of the Auburn University Veterinary Sports Medicine Program, Auburn, Alabama. Their purpose was to develop a Master's program in Biomedical Sciences with a concentration in Veterinary Sports Medicine. She entered the program in the fall of 2006, and was brought on as a student worker in the program during her studies.

THESIS ABSTRACT

EFFECT OF TWO BANDAGE PROTOCOLS ON EQUINE FETLOCK KINEMATICS

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The purpose of this study was to assess the kinematic effects of the Sports Medicine Boot II® and the Twenty X™ Polo Wrap in the forelimbs of horses while trotting. This study provides valuable kinematic data for use in future studies of equine locomotion kinematics and possible extensions of this study. The hypothesis of the study was that applying the Twenty X™ Polo Wrap or the Sports Medicine Boot II® to the forelimb of a horse would result in reduced peak fetlock extension compared to a non-treated limb. Kinematic data was collected from eight horses in this study, 2 Thoroughbreds, 5 Quarter Horses and 1 draft horse cross. The horses had a mean weight of 565.1 ± 57.3 kg, age of 10.0 ± 3.2 years and height of 1.6 ± 0.06 m at the withers. Hemispherical retro-reflective joint markers were placed on the lateral aspect of the elbow, carpal, and

metacarpophalangeal joints, and the lateral aspect of each hoof of the left and right forelimbs.

Horses were filmed while trotting in a straight, level path across an asphalt surface while wearing a Sports Medicine Boot II®, again while wearing a Twenty X™ Polo Wrap, and again with the limbs untreated (control). Kinematic data was evaluated for the forelimb fetlock joint angles. Peak extension, peak flexion, and range of motion of the forelimb fetlock joints were evaluated as parameters. Velocity data was evaluated using a one-way repeated measures analysis of variance (ANOVA). T-tests for left and right trials were analyzed for each horse and each of the three treatments on the forelimbs. A one-way ANOVA was performed to assess the effects of applying the treatments on the forelimb fetlock joints for each of the parameters.

The results of this study indicated that use of the Sports Medicine Boot II® or the Twenty X™ Polo Wrap caused no significant change in peak extension of the fetlock joint. Use of the Sports Medicine Boot II® significantly reduced flexion in the fetlock joint when compared to the non-treated limbs and the limbs to which the Twenty X™ Polo Wrap had been applied. Range of motion in the fetlock joint was significantly decreased with the use of the Twenty X™ Polo Wrap and the Sports Medicine Boot II® when compared to the non-treated limbs. The range of motion, however, was significantly greater in the Twenty X™ Polo Wrap when compared only to the Sports Medicine Boot II®. Reduction in the range of motion of fetlock joint, however, suggests that this boot provides some support to the fetlock. This study has provided valuable kinematic data that documents the changes in the stride of horses at the trot when wearing protective leg gear.

DEDICATION

Mom and Dad, you have been and will always be my greatest mentors. This research is dedicated to you. Thank you for being my biggest fans and pushing me to accomplish my dreams. I express my deepest gratitude and respect for the many years of your dedication to my life. God has truly blessed me with an incredible family!

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INTRODUCTION

Equine locomotion is accomplished biomechanically through the complex interaction of multiple body systems. The horse has innate responses and structures that make locomotion more efficient, such as a lowered body position in the trot and the elastic recoil of tendons in the swing phase (Back, 2001); however, the body systems are fine tuned in athletic and performance horses to create the outcomes that trainers and owners desire. This is often accomplished through years of extensive training that predisposes the horse to musculoskeletal injuries. Injuries may occur from overuse, fatigue, contact with objects or other horses, or problems arising from contact with the bearing surface as a result of poor conformation of the limb, application of shoes, surface composition, or training. Boots and wraps were developed for use during equine sporting events and training sessions to protect musculoskeletal structures and the outer surface of the limb.

Quarter Horses in particular are bred to participate in a variety of speed events such as reining, cutting, roping, and racing. Thoroughbreds are most known for racing, but they also perform as hunters, jumpers, in polo matches, and three-day eventing. Eventing generally includes dressage, show jumping, cross-country, steeplechase, and track phases, requiring a high demand on the body on multiple surface types (Dyson, 2000). These equestrian events and the training that takes place in preparation create

stress on the musculoskeletal structures, give rise to opportunity for damage to the outer body surface, and bring about the possibility for injury from fatigue. Bandages, or wraps, and boots are designed to provide protection to the surface of the lower portion of the limb. In addition, boots are claimed to also provide support to the metacarpophalangeal joint, or fetlock joint. Sports Medicine Boots and polo wraps are commonly used during training, turn out for exercise, and athletic events.

The degree of impact of the limb with the bearing surface during training and athletic events is contingent on a number of factors. The lower portion of the limb is susceptible to high shock waves upon impact (Clayton, 2004). The detrimental results that occur from impact shock waves are affected by structures within the hoof and joints, proper surface composition, training, and shoeing (Clayton, 2004). The structural make-up of the hoof, fetlock joint, ligaments, and tendons are designed to respond to the forces of concussion upon impact (Smythe and Goody, 1993). Surface composition plays a large role in the amount of force that is transferred to the limb. In general, harder surfaces (Williams et al., 2001 as cited in O' Sullivan, 2002) and greater stance time result in greater forces upon impact (Buchner, Savelburg, Schamhardt, Merkens, Barneveld, 1994). An increase in the stance time increases the load placed on the limb. Shoeing also increases the effects of shock on the limb at impact (Benoit et al., 1993, as cited in Clayton, 2004). Benoit et al. (1993) suggested that shock reduction was greater in horses wearing shoes constructed of aluminum and polymer than in steel shoes (as cited in Barrey, 1999). Barrey (1999) suggested that visco-elastic shoes may be beneficial for damping the forces that lead to injury. Understanding the role that distal limb structures, surface composition, training, and shoeing play in the interaction with the bearing surface

is beneficial for maximizing the effects of the Twenty X™ Polo Wrap (Professional's Choice, 2008b) and Sports Medicine Boot II® (SMB II®) (Professional's Choice, 2008a) in producing improved performance.

Little research has been performed to assess the biomechanical effects of protective boots and wraps such as the SMB II®, and similar boots, or even the traditional Twenty X™ Polo Wrap used in trotting horses. The kinematic effects of the SMB II® have been little studied to date because it is relatively new to the equine industry. Kinematic analysis through motion analysis systems provides a way to measure the short-term biomechanical effects of applying boots and wraps to the distal portion of the limb. Measuring limb movement in the sagittal plane gives two dimensional kinematic analyses of joint flexion, extension, and range of motion in the fetlock joint. Two-dimensional kinematic analyses provide data necessary to evaluate the short-term biomechanical effects of boots and wraps.

Purpose of the Study

The purpose of this study was to assess effects of protective leg gear, such as the Twenty X™ Polo Wrap and SMB II®, on the kinematics of the fetlock joint of the forelimb of the horse while trotting. Analysis of temporo-spatial data provided the means to detect significance changes in joint angle data. The examination of angular data of the horses at the trot determined whether or not there were significant changes in the short-term biomechanical effects from these treatments on the distal portion of the limb. This study provided valuable baseline kinematic data for use in future studies of equine locomotion kinematics.

Hypothesis

- There will be a significant difference at the trot in peak fetlock extension after applying a Twenty X™ Polo Wrap or the SMB II® to the forelimbs when compared to a non-treated limb.

Primary Objective

- The primary objective of the study was to compare the short-term biomechanical effects of the following on the fetlock joint of the equine forelimb at the trot: the Twenty X™ Polo Wrap, SMB II®, and a non-bandaged limb.

Secondary Objective

- The secondary objective of the study was to provide kinematic data on the effects of the SMB II® and the Twenty X™ Polo Wrap on the distal portion of the limb at the trot for use in future studies.

LITERATURE REVIEW

Kinematic Analysis

Gait analysis arose out of an interest in understanding the movement of humans and animals (Baker, 2007). Major developments in the twentieth century in the area of kinetic and kinematic analysis arose through the use of force plates (Baker, 2007). Kinetics is “the study of internal and external forces, energy, power and efficiency involved in the movement of a body” (Deuel, 2001, p. xiv). Kinematics is the description of that movement through the study of mechanics such as temporal, angular and linear motion (Clayton, 2004). Although force plates provide valuable kinetic data, they require the researcher to ensure that the horse makes full contact with the plate and to acquire multiple passes of the hoof over the plate in order to collect a sequence of footfalls. Jules Marey’s advancements in recording kinetic data (Baker, 2007), along with Eadweard Muybridge’s motion analysis work, that led to modern kinematic analysis, (Ashley-Ross, 2002) have provided great contributions to gait analysis.

The use of joint markers, videography, and motion analysis systems dates back to Muybridge and Marey’s studies of animal movement, including equine locomotion, in the late 1800s. The continued improvement of gait analysis through the combination of skin markers, videography, and computer-assisted motion analysis systems, along with

the force plate developments cited above, has provided an efficient means to collect both kinematic and kinetic data of sequential footfalls as well as multiple stride cycles.

Analysis of motion of the distal portion of the limb begins with an understanding of equine locomotion. Since the majority of the motion at the fetlock occurs in the sagittal plane, a two-dimensional analysis of peak flexion, peak extension, and range of motion can be performed that will measure the angular displacement of the distal limb during a stride. This analysis also generates necessary kinematic data such as angular, temporal, and linear measurements needed to evaluate the effects of implementing bandage and boot protocols on the fetlock joints of the forelimbs.

Barrey (2001) noted that the horse moves its entire body in repeated patterns through various gaits that are designed for use in sport, work, and pleasure. A gait can be defined as a pattern of limb movements recognized by the sequence and timing of that pattern (Clayton, 2004). Barrey (2001) explained that gaits are commonly divided into symmetrical and asymmetrical gaits depending on the symmetry of the footfalls between the limbs of the left and right sides. The walk and trot are commonly used for kinematic analysis with motion analysis systems because a wider viewing area is not often possible for faster gaits (Barrey, 1999). The trot is a two-beat symmetrical gait in which the diagonal limb pairs move similarly (Clayton, 2004). During the stance phase of the trot, one diagonal limb is in contact with the ground while the other limb is in an aerial phase (Clayton, 2004). During the trot, the horse is moving at a speed faster than a walk, but slower than a canter. The normally symmetrical nature of the trot allows evaluations between the left and right sides because asymmetry indicates lameness. Kinematic

analysis with motion analysis systems may detect asymmetry of gait at the trot that is not detectible to the eye of trained observers.

The development of high-speed video has allowed researchers to capture the phases of the stride cycle in greater detail. These phases include stance, swing and suspension. The stance phase is commonly broken down further into toe down, full contact, breakover, and toe off. The hoof can come in contact with the ground in a toe down, heel-first or flat-footed manner depending on gait, speed and hoof wall angle (Back, 2001). The breed of the horse and leg conformation can also influence the manner in which the hoof-ground contact occurs. It is necessary that the stride cycle events, such as toe down, breakover, and toe off are predefined and that the type of surface is considered when defining these events.

To ensure the accuracy of kinematic data, skin displacement correction factors have been calculated to account for error caused by skin displacement over the joint surface that occurs during locomotion (Van Weeren, Van Den Bogert, and Barneveld, 1990, 1992). Van Weeren et al. (1992) suggested, however, that skin displacement may be disregarded in the lower portion of the limbs, but is necessary for biomechanical research applications. They further claimed that skin displacement appears to be the same in all breeds of horses, but correction models may be necessary when mixed groups of horses are used in research studies (Van Weeren et al., 1990). Clayton and Schamhardt (2001), however, claimed that skin movement below the elbow in the forelimb does not require the use of correction factors. The research cited above on skin displacement is debatable. There are conflicting conclusions on the subject of skin displacement

correction factors in the distal portion of the limb within the cited literature. More research is needed for clarification of this issue.

Surfaces used in the production of kinematic data must also be considered. The treadmill has often been used in kinematic analysis as a tool for researchers because of its ease of use in an indoor, more controlled, environment (Buchner et al., 1994). The treadmill usually has a relatively flexible rubber surface. Buchner et al. (1994) observed that on an asphalt surface the duration of the stride was shorter, but the shock of impact was higher than on a rubber surface. Asphalt surfaces have been the standard for lameness evaluations (Buchner et al., 1994). Data collected from over ground locomotion studies, however, can not be quantitatively compared to data collected in treadmill studies (Buchner et al., 1994). Therefore, caution should be used when comparing data from horses trotting on a treadmill and horses trotting over ground while using similar protective leg gear.

The Distal Portion of the Equine Limb

When a horse's head and neck are in a neutral position, the forelimbs bear more weight than the hind limbs, and the center of mass lies closer to the cranial aspect of the body (Clayton, 2004). Because a horse's center of mass lies in this position, peak vertical ground reaction forces will be greater in the forelimbs. Vertical ground reaction forces peak around mid-stance, at the time when the suspensory ligament undergoes maximal strain (Clayton, 2004). Peak vertical ground reaction forces increase with an increase in trotting speed, resulting in higher forces upon impact and having the propensity to result in greater extension of the fetlocks of the forelimbs (Clayton, 2004). The structures of the

equine forelimb also undergo higher maximum braking forces since braking occurs primarily in the forelimbs (Clayton, 2004).

The fetlock joint consists of the junction between the third metacarpal bone and the proximal phalanx, as well as the junction between two sesamoid bones located proximal and caudal to the joint and the distal portion of the third metacarpal bone (Dyce, 2002). Weight is distributed across the sesamoids and the proximal phalanx to reduce impact forces on the joint (Dyce, 2002). The primary sources of stabilization and support during movement in the forelimb fetlock joint arise from the proximal sesamoid bones, and elastic properties of the suspensory ligament, and extensor branches of the suspensory ligament (Stashak, 2002). Support is also provided by the superficial and deep digital flexor tendons (Clayton, 2004). The superficial digital flexor tendon allows for fetlock flexion during the swing phase and extension of the fetlock joint during the stance phase (Clayton, 2004). The superficial digital flexor tendon is an extension of the superficial digital flexor muscle and inserts on the first and second phalanxes (Clayton, 2004).

The fetlock joint, allows for movement in the sagittal plane through the actions of tendons and ligaments surrounding the joint, in addition to muscle function occurring in the upper portion of the limb (Back, 2001). The fetlock joint moves through a combination of negative and positive work (Clayton, 2004). As the horse moves into the stance phase active energy is transferred to the limb and energy is stored in the tendons and suspensory ligament (Clayton, 2004). During the latter portion of the stance phase, positive work is done, and energy is released as these tissues recoil (Clayton, 2004). Back (2001) claimed that the passive release of energy from the recoiling of the SDFT and

DDFT throughout the stride is also involved in causing flexion and extension of the fetlock joint. Clayton (2004) suggested that the storage and release of energy during the stance phase is a means of energy efficiency for the horse during locomotion.

The suspensory ligament, deep and superficial digital flexor tendons, and their accessory ligaments store elastic strain energy during limb loading in the stance phase (Back, 2001). It is at this time that the fetlock undergoes maximal extension and the suspensory ligament, superficial digital flexor tendon, and deep digital flexor tendon undergo maximal strain (Back, 2001). Because the superficial digital flexor tendon experiences maximal tension in the stance phase (Meershoek et al., 2002a as cited in Clayton, 2004), it is at this point that injury caused by hyperextension is likely to occur (Clayton, 2004). Elastic strain energy that is stored in the limb during the stance phase supplies kinetic energy sufficient to allow for passive fetlock flexion during the swing phase (Back, 2001). Inertial forces primarily drive fetlock flexion in the latter part of the swing phase and forward limb movement continues until the proximal portion of the limb slows before ground contact (Back, 2001). Flexion continues until anatomical constraints, namely the tendons and ligaments on the caudal aspect of the limb, halt the ability of the limb to continue swinging forward (Back, 2001).

The hoof is designed to provide energy absorption through its elastic properties and transmit forces to the rest of the skeleton (Thomason, Biewener and Bertram, 1992). Hoof wall distortion is the same regardless of speed or gait (Thomason et al., 1992), however both hoof wall angles (Clayton, 1990) and shoes play a major role in the surface interface interaction (Barrey, 1999).

Surface Impact

Quarter Horses and Thoroughbreds participate in a number of athletic performances that subject them to extreme ground contact forces, predisposing them to a greater risk for injury. Anatomical structures resist the forces placed on the body during locomotion. Detrimental results that occur from impact shock waves are affected by structures within the hoof and joints, surface composition, training, and shoeing (Clayton, 2004).

Body-to-surface interactions. As the hoof comes in contact with the ground, damping of impact forces occur mainly in the metacarpophalangeal joint (Merkens and Schamhardt, 1994). Damping of impact oscillations, however, occur in the suspensory apparatus, hoof and the contact surface (Merkens and Schamhardt, 1994). The hoof has elastic properties that allow for deformation in the wall upon impact with the ground, resulting in energy absorption capabilities that are not dependent upon direction of impact (Thomason et al., 1992). Energy absorption is accomplished in other portions of the foot due in part to the role of the soft tissues of the hoof, laminae, and digital cushion in attenuating the frequency of the impact vibrations (Lanovaz, Clayton, Watson, 1998). The bones of the equine digit and interphalangeal joints attenuate amplitude to a greater extent than they attenuate frequency (Lanovaz et al., 1998). The hoof's capabilities in providing this natural shock absorption somewhat protect the distal portion of the limb from the damaging impact forces.

Effect of surface composition on strain. A case could be made that there are four major surface classifications used in the equine industry. The classifications are vegetated, non-vegetated, asphalt/concrete, and synthetic athletic surfaces. Vegetated

surfaces are defined as “areas having equal to, or greater than 1% or more of the land or water surface with live vegetation cover at the peak of the growing season” (Federal Geographic Data Committee, 2008, p.57). According to the National Vegetation Classification Standard, non-vegetated surfaces have “less than 1 % of the surface area with vegetation cover naturally or from which vegetation is removed and replaced by man (human)-made surfaces or structures” (Federal Geographic Data Committee, 2008, p. 52). Asphalt is a petroleum byproduct that may be mixed with stone or sand (“Asphalt”). Concrete is derived from mixture of cement, gravel (“Concrete”, *The American Heritage® Dictionary*), and water to form a thick mortar (“Concrete”, *Collins Essential English Dictionary*). Synthetic or athletic surfaces used in the equine industry are commonly formed from silica sand, rubber, synthetic fibers, such as elastic, and wax coatings. These surfaces are used to increase the consistency of the track surface and are thought to reduce the number of injuries that occur on the track arising from issues with the level of consistency (Thomason and Peterson, 2008).

With regard to the vertical ground reaction force loading rate, surface stiffness is a more important factor of track composition than the addition of other organic substances that are normally added to enhance damping (Reiser, Peterson, McIlwraith, Woodward, 2000). The surface area of the hoof that comes in contact with the track will influence loading of the ground reaction forces to the bones and joints (Reiser et al., 2000). If there is a deficiency of surface area contact with the hoof, the vertical loading forces may mimic a significantly harder soil or surface, exposing the horse to a greater risk for injury (Reiser et al., 2000). Overall, harder surfaces and those that are unstable create the most risk for damage to the limb. (Williams et al.,2001 as cited in O’Sullivan, 2007). In

addition, increasing the stance time will consequently increase forces on the limb upon impact (Buchner, et al 1994).

Training Effects. Exercise has the beneficial physiological effects of increasing bone density, increasing the size of tendons, and an even greater response in changing hyaline cartilage within joints (Firth, 2006). The type of exercise, duration, intensity, frequency, length of the regimen, and recovery time should be included in an exercise prescription (Rogers, Rivero, van Breda, Lindner, and Sloet van Oldruitenborgh-Oosterbaan, 2007). Burn, Wilson, and Nason (1997) suggested that dynamic limb loading causes bone changes that result in greater bone strength. Increasing the speed and allowing the horse to travel over hard surfaces increases the shock that occurs upon impact due to the deceleration of the hoof (Clayton, 2004). Radin (1991) found that repetitive exposures to oscillations that occur upon impact are linked to the development of osteoarthritis (as cited in Back, 2001).

Shoeing Effects. The type of shoe selected may increase or decrease the shock upon impact (Benoit et al., 1993 as cited in Clayton, 2004). Benoit et al. (1993) suggested that shock reduction was greater in horses wearing shoes made of aluminum or polymer than in steel shoes (as cited in Barrey, 1999). Barrey (1999) suggested that visco-elastic shoes may be beneficial for damping the forces that lead to injury. Iron shoes increased both the amplitude and frequency of the impact vibrations when horses were trotted on an asphalt surface (Dyhre-Poulson, Smedegaard, Roed, and Korsdgaard, 1994). According to Willemen (1999), shod horses had a greater flexion of the carpal and fetlock joints during the swing phase than unshod horses (as cited in Singleton, Clayton, Lanovaz and Prades, 2003).

Bandages and Boots

The distal portion of the forelimb of horses is predisposed to many different types of injury at the fetlock joint including fractures of the third metacarpal, proximal sesamoid bones, and the proximal phalanx in response to stress placed on the limb during locomotion. Fatigue and the subsequent hyperextension of the fetlock joint are often cited as the cause of injury to the fetlock and supporting ligaments and tendons (Kobluk, Martinez, Harvey-Fulton, Libbey, and Walton, 1988). Fractures of bones and trauma to tendons and ligaments commonly occur in athletic horses.

Bandages, or wraps, and boots are used for protective, supportive, therapeutic and clinical treatment purposes on the lower limb. It is important that boots and bandages are expertly applied to avoiding causing further injury and to achieve the desired treatment outcome (Harris, 1997a). We are not aware of studies investigating the ability of the SMB II® and the Twenty X™ Polo Wrap to prevent injury to structures in the forelimb in trotting horses over ground. It is widely accepted, however, that support boots and polo wraps are an effective means of protection from injury during training and are allowed to be worn in some equine athletic events. The SMB II® and the Twenty X™ Polo Wrap were selected for this study because they are commonly used at equine athletic events and are believed to prevent injury to the lower portion of the limb. The SMB II®, which is made from a synthetic neoprene material, is fastened using three straps that circle the third metacarpal bone and another strap that circles the fetlock just below the proximal sesamoid bones. Twenty X™ Polo Wraps are made of long, narrow strips of fleece material, usually with one Velcro strap, and appear to be more flexible than support boots. Polo Wraps conform to contours of the limb without the need for additional

padding that other wraps require (Harris, 1997a). Support boots are claimed to support the fetlock by reducing fetlock hyperextension (Balch et al., 1998). Polo wraps on the other hand do not provide support to the fetlock, and thus provide less protection than boots (Clayton as cited in Loving, 2008).

When considering selection of a boot or wrap, it is important to take into account the type of work the horse will be performing, the amount of interference needed to prevent further injury, material composition of the boot or bandage (Crawford, 1990a), and the fitness of the horse. Crawford (1990a) and Morlock (1997) suggested that the technique of application and the types of surfaces for training and performance are also important considerations when choosing a boot or wrap. Furthermore, each event's governing organization has policies that dictate what equipment is permissible. For example, boots and wraps are allowed in cutting, roping, reining, but boots are restricted to training areas only in many dressage competitions.

Boots are useful during training and competition, but careful selection should be made to select boots that provide optimal support to the distal portion of the limb. There are two categories of boots, interference and support boots. Brushing or interference boots include bell boots, skid, splint, and jumping boots (Nicodemus, 1999). Older style bell boots are fashioned from rubber-like material and are commonly used to prevent injuries from interference. Skid boots are applied to horses used for cutting and reining to protect from chafing of the fetlock during slide stops, but care must be taken so that dirt does not collect in them and exasperate the problem of chafing (Biggs, 2002). Splint boots are used for protection of the medial aspect of the distal portion of the limb through the use of a rigid plate (Biggs, 2002). Jumping boots are often open to the front to allow

the horse to feel poles when coming in contact with them and closed in the back to protect the tendons from rear leg strikes (Biggs, 2002) and contact with obstacles while jumping. Sports Medicine Boots are categorized as a support boot (Nicodemus, 1999) and have been shown to provide energy absorption capabilities as measured by Balch et al., 1998.

Bandages were developed out of the need for wound care, rehabilitation, and safety in transportation (Gomez and Hanson, 2005). Few are designed to provide support, but do provide protection to the limb surface. Bandages are made from various materials and include dressings, shipping bandages, polo wraps and athletic tapes. Bandages should be used according to the type of event the horse will participate in and the type of injury that the horse is prone to. Bandages are used in both people and horses for rehabilitation, wound care, and stabilization of joints and ligaments. Athletic taping is used for the purpose of enhancing stability and strength of joints in humans (Neiger, 1990 as cited in Ramon et al., 2004). Ramon et al. (2004) compared common athletic taping materials to assess the effects of taping the metacarpophalangeal joint of horses while trotting on a rubber surface. They found that fetlock flexion during the swing phase and vertical loading forces are reduced by use of athletic taping; however, there was no significant reduction of extension of the metacarpophalangeal joint during the stance phase (Ramon, 2004). The reduction in peak vertical force was suggested to be caused by a change in proprioception (Ramon et al., 2004). Kobluk et al. (1988) found that bandaging with Vetrap® support bandage (Equisport Equine Support Bandage: 3M Corporation) reduced fetlock extension when horses were exercised to fatigue on a high-speed treadmill while imitating racing conditions.

Support boots, and bandages are used frequently on the equine athletes to prevent injury and provide support (Kicker, Peham, Girtler, and Licka, 2004). Substantial vertical impact forces on the distal portion of the forelimb during the trot predispose the horse to injury (Back, 1995), but this injury may be prevented by the use of bandages (Kobluk et al., 1988; Ramon et al., 2004) and support boots (Kicker et al., 2004). The application of support boots has been shown to reduce maximum fetlock extension and tension on the superficial digital flexor tendon (SDFT) of horses trotting on a treadmill (Kicker et al., 2004). The risk for overload of the SDFT, a common cause of injury in performance horses, may be reduced by use of support boots (Kicker et al., 2004). Long-term use of support boots for the purpose of rehabilitation and protection of SFDT injuries, however, may decrease the chance for proper healing (Kicker et al., 2004). Serious injury can occur to the bones and joints of the forelimb as a result of impact with the ground due to high frequency, high amplitude shock waves (Luhmann et al., 2000). Luhmann et al. (2000) found that use of a neoprene type, nylon-lined boot or a polo wrap did not attenuate shock in the third metacarpus of horses that were trotted and galloped on a high-speed treadmill. They suggested that further studies were needed to determine the effects of boots and wraps on the distal portion of the limb when used for an extended period of time (Luhmann et al., 2000).

The material composition of commercial equine support boots has been found to be a significant factor in their ability to absorb energy (Crawford, 1990b). Crawford et al. (1990a) suggested that for a support boot to be useful, it is important to select a material with a higher modulus of elasticity, and wrap with the proper tension, thickness, and technique, including direction. Crawford (1990a) used Vetrap® Bandaging Tape (3M

Corporation) in different bandage configurations on equine cadaver limbs. Five configurations were applied with varying tensions and application techniques. Crawford et al. (1990a) suggested that assessing the purpose for bandage application is beneficial before selecting the bandage configuration. Energy absorption capacity is affected by selecting the proper tension and application technique (Crawford, 1990a). In particular, Crawford et al. (1990a) reported that racing Thoroughbreds are often wrapped with Vetrap bandaging tape applied at 50% tension using a high “figure 8” technique. They suggested that adding a splint support to this would enhance the energy absorption capacity of the bandage (Crawford et al., 1990a). In a subsequent study Crawford, et al. (1990b) outlined situations in which certain bandaging configurations and tension applications may be more beneficial. They suggested that maximal energy absorption capacity often occurs in applications may restrict mobility in the joint (Crawford et al., 1990b). Balch et al. (1998) found that Sports Medicine Boots (Professional’s Choice Sports Medicine Products, Inc.) protect supporting structures in the lower portion of the limb by absorbing energy from ground reaction forces. Balch et al. (1998) measured the energy absorption capacity of the SMB II® (Professional’s Choice Sports Medicine Products, Inc.) and previously worn SMB II® in their trials. Balch et al. (1998) calculated the energy absorption capacities of the SMB II using load/deflection curves, and reported data as a percentage to represent the mean increase of the energy absorption capacity of the bandaged limb to a non-bandaged limb, predicted through calculation. The SMB II® was shown to increase the energy absorption capacity of an isolated hindlimb upon impact with the surface by 23.4% and previously used SMB II® increased the energy absorption capacity by 26.4% (Balch et al., 1998).

MATERIALS AND METHODS

Horses

Kinematic data was collected from eight horses in this study (2 Thoroughbreds, 5 Quarter Horses and 1 draft horse cross). This study was approved by the Auburn University's Institutional Animal Care and Use Committee. The horses had a mean weight of 565.1 ± 57.3 kg, an age of 10.0 ± 3.2 years and a height of 1.6 ± 0.06 m at the withers. The horses had no signs of lameness when observed while trotting on a level asphalt surface in a straight line.

Procedure

Each horse was trotted on the asphalt surface to acclimatize it to the handler and surroundings and to determine that it was not lame. A treatment was then selected and implemented according to the treatment order. The treatment order was designed to counterbalance the effects of fatigue during the trials.

The SMB II® and the Twenty X™ Polo Wrap were selected for this study. The SMB II®, which is made from a synthetic neoprene material, has three straps that circle the third metacarpal bone and one strap that circles the base of the fetlock joint on its caudal aspect. Twenty X™ Polo Wraps are made of a fleece material, 5 inches wide and 9 feet long, which is secured to the limb with one Velcro strap. Polo wraps appear to be

more flexible than support boots, and they conform well to the limb without the need for additional underlying material that other bandaging materials require (Harris, 1997a).

Twenty X™ Polo Wraps were applied by the lead graduate student (see Appendix) according to the method described by Luhmann, et al. (2000). SMB IIs® were applied by the lead graduate student according to the first protocol shown in an instructional video (Professional's Choice, 2008c). The horse was trotted in a straight line between timing gates, in a path in front of and perpendicular to the view of a video recorder. Six film sequences were collected for each of the three treatment groups [i.e., SMB II®, Twenty X™ Polo Wrap, non-treated limbs (control)]. Six video taped sequences (three left and three right body side views) were recorded of each horse while trotting for data analysis.

Electronic timing gates (Signature Gear Corporation) were placed at the start and finish of the motion path to record the time that the transmitted beam is broken at the start until the beam is broken at the finish. The start gate and finish gate each had two poles placed on either side on the horse's path to create a 6-meter wide gate. The start gate poles were placed 9.27 m from the finish gate poles (Figure 1). Data from the timing gates were recorded to calculate velocity for each pass for all treatments and horses.



Figure 1: The finish timing gate for a left side view of the horse.

For the purposes of analysis, stride cycle events were predefined prior to the study. One stride was determined to occur from toe down to toe down in the same limb. Toe down occurred at the frame in the video where initial contact occurred between the hoof and the asphalt surface. Toe off was defined as first frame in the video in which the hoof left contact with the bearing surface. Breakover was defined as the first frame in which the heel bulb left the ground after full contact with the bearing surface in the stance phase.

Equipment

Retro-reflective markers were placed on the lateral aspect of the elbow, carpal, and metacarpophalangeal joints, and the lateral aspect of each hoof of the left and right forelimbs (Figure 2). Elbow markers were placed over the lateral epicondyle of the left and right humeri. Markers for the carpii were placed over the lateral styloid process. For the fetlock joints, the marker was placed at the distolateral aspect of the third metacarpal

bones. Hoof markers were placed on the lateral aspect hoof midway between the coronet and the bearing surface. Two Smith and Victor model 700 SG lights were placed on either side of the high-speed camera to increase marker reflection properties.



Figure 2: Skeletal view of a forelimb with markers applied

When treatments were applied, the site of marker application was identified by palpating the fetlock through the wrap (Figures 3 and 4). Each marker had a circular base constructed of a foam circle glued to reflective duct tape (Polyken® FSK). A one and one-half inch hemispherical retro-reflective object was attached to this base for each marker. The markers had adhesive backings and were placed directly onto the skin (Figures 3 and 4). At least three video-recorded sequences for both the left and right sides of the horse were collected as the horse trotted perpendicular to the view of the camera for each of the three treatment groups.



Figure 3: Thoroughbred with markers applied to treated and untreated limbs



Figure 4: Quarter Horse with a marker applied over a SMB II

Video of the study was obtained through the use of a TroubleShooter portable high-speed camera (Fastec Imaging™ Corporation). The high-speed camera was set at a rate of 60 pictures per second (pps) and a shutter speed of 1/600, 10 times the frame rate. Uncompressed audio video interleave (avi) files produced from this camera were analyzed through the Peak Motus® 8 motion analysis system. Positional data was generated, allowing for assessment of linear and angular displacement measurements on the forelimb fetlock with each protective/supportive implementation, and with no bandage.

Statistical analysis

Data from gait timers was validated by using positional data from the withers marker for one horse and the known gait distance in the Peak Motus® 8 motion analysis system. Velocity data for all eight horses was processed using SigmaStat 2.03 statistical software to validate combining left and right trials in the one-way repeated measures ANOVA analysis. A one-way repeated measures ANOVA was performed to detect significant variance in the horses' velocities for both of the treatments and the control variable. The one-way repeated measures analysis of variance was performed in SigmaStat 2.03 statistical software for the fetlock joint angles using the 8 subjects to compare the biomechanical effects of the two bandages and the non-treated limbs. The kinematic parameters for this study included the following: peak extension, peak flexion, and range of motion (ROM). The left and right sides were combined for all eight horses.

RESULTS

Gait timers were validated by using positional data from the withers marker for one horse and the known gait distance. T-tests were run to further detect any differences in the velocities between left and right sides for the control for all eight horses. No significant differences were found for the control ($p > 0.05$). T-tests were also performed on left and right trials for the fetlock joint angles for each of the kinematic parameters. No significant differences were found for the joint angles in the left and right trials comparison ($p > 0.05$). A one-way analysis on angular data for the fetlock joints is shown in Table 1. The results of this study indicated that there was no significant change in peak extension of the fetlock joint caused by application of the SMB II® or the Twenty X™ Polo Wrap ($p = 0.143$). Peak flexion in the fetlock joint was reduced significantly with the use of the SMB II® when compared to the non-treated limb ($p = < 0.001$) and the Twenty X™ Polo Wrap ($p = 0.004$). Range of motion of the fetlock joint was significantly decreased with the use of the Twenty X™ Polo Wrap and the SMB II® when compared to the non-treated limb ($p = < 0.001$); however, range of motion of the fetlock joint was significantly greater in horses wearing the Twenty X™ Polo Wrap when compared to range of motion of the fetlock joint in horses wearing the SMB II® ($p = < 0.001$).

Table 1: One-way repeated measures ANOVA results for the fetlock joint of horses wearing a Twenty X™ Polo Wrap, or Sports Medicine Boot II® (SMB II®), or wearing no support device (control) based on the mean angular joint data.

	Fetlock			
	M	SD	P	F
Peak Ext.			0.14	2.08
Control	229.71	6.11		
Polo	227.57	6.49		
SMB II®	226.63	6.46		
Peak Flex.			<0.001	17.91
Control	155.28	5.66		
Polo	158.58	8.40		
SMB II®	163.49	7.34		
ROM			<0.001	63.50
Control	74.4	6.76		
Polo	68.99	6.38		
SMB II®	63.13	6.65		

Notes: Ext. = Extension, Flex. = Flexion, ROM = Range of motion, M = mean, SD = Standard deviation.

Figure 5: Mean fetlock joint angles for one complete stride during motion analysis of the control.

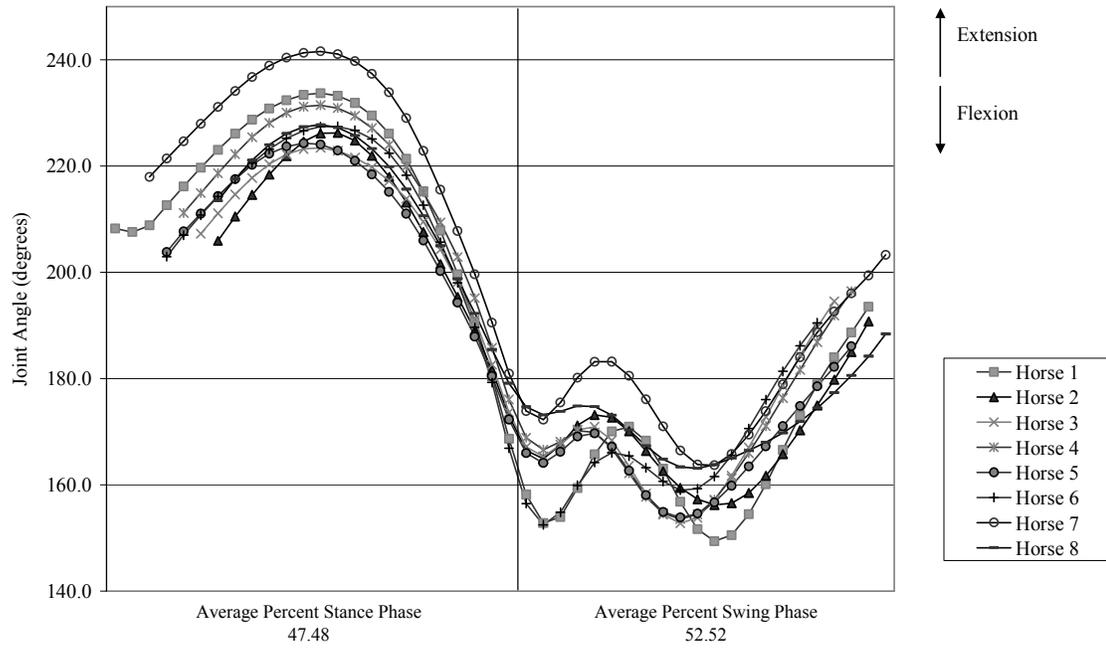


Figure 6: Mean fetlock joint angles for one complete stride for horses trotting while wearing a Sports Medicine Boot II ®.

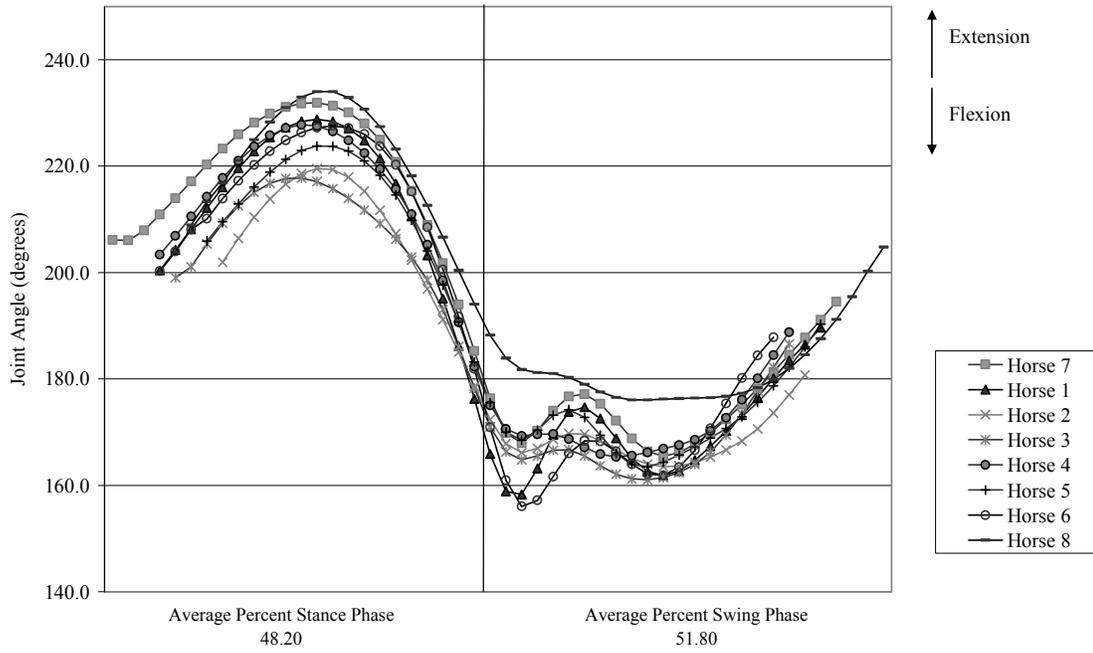
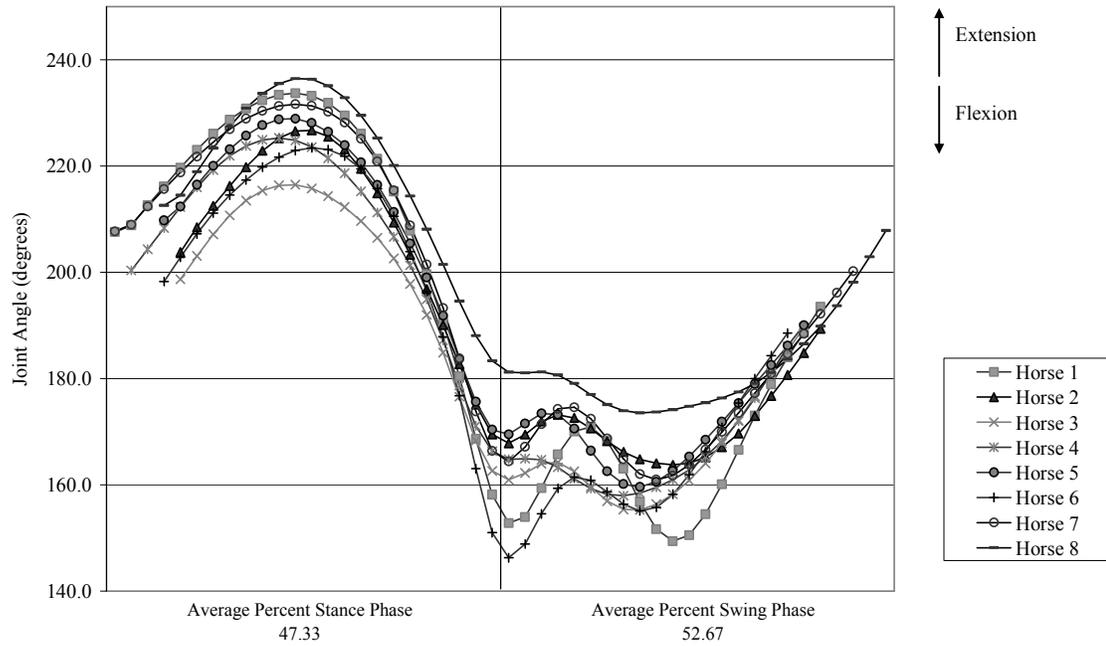


Figure 7: Mean fetlock joint angles for one complete stride for horses trotting while wearing a Twenty X™ Polo Wrap.



DISCUSSION

The objective of this investigation was to test the hypothesis that the use of the SMB II® and the Twenty X™ Polo Wrap would reduce peak extension in the fetlock joint at the trot. Horses were trotted in this study because this gait provided adequate velocity, which allowed for substantial kinematic assessment of temporal and spatial parameters while providing a symmetrical gait to allow comparison of fetlock flexion and extension in each of the forelimbs, and detection of lameness prior to the start of the study. Preliminary statistical analysis of the horses' velocities indicated that there were no significant differences between each of the horses' left and right trials for the control treatment. This validated the combination of left and right sides in the one-way repeated measures ANOVA analysis for the fetlock joint angles.

To further test the validity of combining the left and right trials, t-tests were performed on data collected during left and right trials that examined fetlock joint angles for horses trotting while wearing the SMB II®, or Twenty X™ Polo Wraps, or control horses under each parameter; no significant differences in results were found for fetlock angles for peak extension, peak flexion, or range of motion under the treatment or control conditions. A one-way repeated measures ANOVA revealed that extension of the fetlock joint is not significantly reduced by use of the SMB II® or the Twenty X™ Polo Wrap.

The application of support boots has been shown to reduce maximum fetlock extension and tension on the superficial digital flexor tendon (SDFT) when horses are trotted on a treadmill (Kicker et al., 2004). The results of this study, however, showed no significant reduction in peak fetlock extension in horses trotting while wearing these protective care products, which may suggest that these boots and wraps do not offer additional support to the SDFT during motion more comparable to regular training activities than motion on a treadmill. As expected, flexion was reduced with the use of the SMB II® when compared to the other two treatments. Range of motion in the fetlock joint was reduced by the Twenty X™ Polo Wrap by 5.43 degrees when compared to the control in this study. The SMB II® caused a greater reduction in range of motion (11.3 degrees) when compared to the control. We conclude that the Twenty X™ Polo Wrap permitted a significantly greater range of motion than the SMB II®.

The suspensory ligament and flexor tendons experience strain as a result of fetlock joint extension (Denoix, 1996 as cited in Ramon et al., 2004). Polo wraps, by nature, offer protection to the outer distal limb surface; however, there is considerable debate concerning the degree of support, if any, that polo wraps offer due to the pliable properties of their materials. Based on the results of this study, there is no evidence to suggest that either the Twenty X™ Polo Wrap or the SMB II® offer any support sufficient to reduce strain on the suspensory ligament and flexor tendons that occur as a result of peak fetlock extension. Sports medicine boots, like the SMB II®, have been shown to provide energy absorption capabilities (Balch et al., 1998). The results of this study indicate that use of either the SMB II® or Twenty X™ Polo Wrap significantly restricts the range of motion in the fetlock joint by reducing peak flexion. Back (2001)

found that there are two peaks of flexion in the fetlock joint during the swing phase, with maximal peak flexion reached at around $\frac{3}{4}$ of the swing phase. The present study found that maximal peak flexion is reduced by both treatments. Further studies are necessary to confirm changes in the timing of peak flexion under the influence of the SMB II® or the Twenty X™ Polo Wrap.

The findings of this study suggest that additional care should be taken when choosing wraps and boots for training, treatment, or competition to achieve the desired outcome. This study did not evaluate the addition of protective leg gear in providing protection to the outer surface of the limb, but it does show that use of these treatments restricts motion. If motion is restricted during the stance phase, the forces placed on structures within the limb may be increased (Buchner et al., 1994). Clayton (2004) suggested that detrimental results that occur from impact shock waves are affected by structures within the hoof and joints, surface composition, training, and shoeing. Future studies should investigate how these factors are affected by use of boots and wraps such as the SMB II® and the Twenty X™ Polo Wrap.

Boots, such as the SMB II®, and the Twenty X™ Polo Wrap were designed to provide protection to the outer surface of the limb during equine sporting events and training sessions. Boots have also been claimed to provide support to the fetlock joint. For these reasons, these protective leg care products are commonly worn by Thoroughbreds and Quarter Horses in training, when turned out for exercise, or during competition. It is during these times that the musculoskeletal structures of the forelimbs undergo extreme forces, sufficient to cause injury. These forces are affected by a variety of factors including, but not limited to, the structures within the hoof and joints, surface

composition, training, and shoeing (Clayton, 2004). The benefit of the surface protection versus the limitation on movement must be carefully assessed when determining the use of protective materials during training and competition. Roping and cutting horses may lose some of the precision of movement necessary to accomplish their goals due to a reduction in flexion or range of motion. This may also result in time limitations caused by restricted movement in the joint. In roping and cutting horse events, restricting movement may jeopardize the quick movements necessary to accomplish the task, costing the rider and horse time in a competition and consequently money. This study provides objective data that will aid in such assessments. Since it is practically impossible to measure the effects of inhibiting range of motion during the actual competitions in an objective manner, studies in carefully controlled environments can only assess components of the movements expected during competition.

During our literature search we found no report concerning the effects that the Twenty X™ Polo Wrap or SMB II® have on fetlock joint kinematics for horses trotting on asphalt surfaces. Data from treadmill studies can not be quantitatively compared to data collected in over ground studies (Buchner et al., 1994). Therefore, this study is valuable in providing much needed kinematic data on movement of horses trotted on an asphalt surface for the comparison of the movement affected by application of the SMB II® and the Twenty X™ Polo Wrap versus movement of non-treated horses.

In further assessments of the SMB II®, it is important to note that circumference of the fetlock at the widest point is more important than height in assessing which size of the SMB II® to use (Professionals Choice, 2009). The present study relied on measurement of the horse's height in hands for proper fitting of the boots, so fit may

affect the results. Furthermore, although there is no established direction for applying the polo wraps, this study chose to wrap the Twenty X™ Polo Wraps counterclockwise when wrapping the left forelimb and clockwise when wrapping the right.

Future research may include investigation of the movement of the carpus, elbow, shoulder, ear, withers, ilium, hip, stifle, tarsus, and hoof to determine the short-term biomechanical effects of these treatments on the movement of the body as a whole through evaluation of kinematic parameters. Kinematic and kinetic evaluations on stance phase durations may be beneficial in determining how forces on the limb are affected by using these treatments.

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APPENDIX: Institutional Animal Care and Use Committee Approval Form

APPROVED
2008-1393



ANIMAL SUBJECTS REVIEW FORM

PRINCIPAL INVESTIGATOR: Robert Gillette DVM MSE

RANK/TITLE: Director
DEPARTMENT: Clinical Sciences
COLLEGE/SCHOOL: Veterinary Medicine
CAMPUS ADDRESS: McAdory Hall
CAMPUS PHONE #: (334) 844 5646

E-MAIL ADDRESS: gillerl@vetmed.auburn.edu
FAX #: (334) 844 6084

_____ Check if PI will serve as faculty advisor to the Lead Graduate Student or Resident associated with this activity.

LEAD GRADUATE STUDENT/RESIDENT:

RANK/TITLE: Jennifer Sanders BS BA
DEPARTMENT: Clinical Sciences
CAMPUS PHONE #: (334) 844 5646

E-MAIL ADDRESS: sandejs@auburn.edu
FAX #: (334)844 6084

CO-INVESTIGATOR:

RANK/TITLE:
DEPARTMENT:
CAMPUS PHONE #:

E-MAIL ADDRESS:
FAX #:

PROJECT TITLE: "Effect of Two Bandage Protocols on Equine Fetlock Kinematics"

STARTING DATE: 5/25/2008
(Must not be prior to IACUC approval)

EXPIRATION DATE: 5/25/2010
(Must not exceed three years)

Is any part of the funding from a U.S. Public Health Service Agency: Yes _____ No X

REQUIRED SIGNATURES

The information contained on this form provides an accurate description of the animal care and use protocol which will be followed. I agree to abide by governmental regulations and university policies concerning the use of animals. I will allow veterinary oversight to be provided to animals showing evidence of pain or illness. If the information provided for this project concerning animal use should be revised, or procedures changed, I will so notify the committee of those changes in writing, and no proposed changes will be implemented until full IACUC approval has been granted.

[Signature] 3-24-08
Principal Investigator Date

Medical care for animals will be available and provided as indicated by a qualified veterinarian. By accepting this responsibility, the veterinarian is providing assurance that any personal interest he/she might have in the project will not conflict with his/her responsibility for the provision of adequate veterinary care for the animals. Furthermore, the veterinarian provides assurance of review and consultation on the proper use of anesthetics and pain relieving medications for any painful procedures.

[Signature] 3/25/08
Project Veterinarian Date

Jennifer Taintor
Project Veterinarian (Please type or print)

[Signature] 3/26/08
Departmental Chairperson Date

[Signature] 3/24/08
Lead Graduate Student/Resident Date

[Signature] 5/25/08
*IACUC Chair Date

*IACUC Chair signs the protocol after IACUC approval has been granted.

MAR 26 2008

MAY 01 2008

ASRF 09/01/00
Page 1

PLEASE TYPE IN BOLD FONT AND COMPLETE THE FOLLOWING FORM IN FULL.

1. Will the animals be used in:

Teaching _____
 Research _____ **X** _____
 Demonstration _____
 Production _____

If Teaching, give the course number:

2.

Species Common Name	Total Number	Source	Housing Location
Horse	6	Large Animal Clinic Equine herd PRN 2006-1069	Large Animal Clinic Research Horse Barns

3. Will animals be maintained for a period of 12 or more consecutive hours in a location other than the housing location mentioned in Item 2? (See Item 3 of Additional Information at the end of this form.)
 Yes _____ No **X**

If Yes, specify the location and reason.

4. PERSONNEL QUALIFICATIONS (See Item 4 of Additional Information at the end of this form.)

A. Indicate who will provide daily care and maintenance of the animal(s). Indicate name(s) or identify the particular unit staff.
Mike Coley and staff

B. List the names of all individuals who will conduct procedures involving animals on this protocol. If all individuals are not currently known, please indicate as such.
Robert L. Gillette, Jennifer S. Sanders, and Dr. John Schumacher have completed the LATA Laboratory Animal and Laboratory Dog training modules

C. Principal Investigator Certifications
Dr. Robert Gillette is a licensed veterinarian who graduated with a DVM from Kansas State University in 1988 and a MSE in Biomechanics in 1998 from Kansas University. He worked as an Associate Lab Animal Veterinarian at the University of Kansas from 1989-1992.

My signature on page 1 of this form certifies that:

- 1) Individuals performing animal procedures on this protocol are or will be qualified to perform their particular animal related duties through training and/or experience (individuals will be supervised until adequate training has occurred). Training and/or experience must encompass the following: *biology, handling, and care of the species; aseptic surgical methods and techniques (if applicable); the concept, availability, and use of research or testing methods that limit the use of animals or minimize distress; the proper use of anesthetics, analgesics, and tranquilizers (if applicable); and procedures for reporting animal welfare concerns. Informative links regarding training resources have been provided for assistance as needed at <http://www.auburn.edu/research/vpr/animals>.
- 2) All individuals working with animals, animal tissues, or animal products on this protocol will be informed of relevant *occupational health and safety issues prior to performing their duties. * Informative links have been provided for assistance in this and other areas as needed at <http://www.auburn.edu/research/vpr/animals>.

5. State how or why you selected the species to be used in this project.

The study is based on horses and no other species would supply information of value.

6. STUDY/ACTIVITY JUSTIFICATION AND OBJECTIVES:

A. Justification:

Wrapping of the fetlock joint is a common practice in athletic events, training and exercise to prevent injuries and provide support of tendons and ligaments. The activities performed may predispose the horse to injuries to the fetlock and surrounding ligaments and tendons. Fetlock wraps and support boots are used because they are thought to provide a protective covering for the fetlock joint and support structures, as well as protect from injury to the skin. We are interested in learning the effects, whether beneficial or detrimental, these fetlock wraps and support boots may have on the biomechanics of the fetlock joint.

B. Objectives:

The purpose of this study is to determine the short-term biomechanical effects of two types of fetlock wraps and support boots commonly used in horses on the fetlock joint.

7. SUMMARY OF PROPOSED ACTIVITY: USE LAY TERMS to give a description of the proposed activity. *From reading this section it should be possible for a non-scientist to determine exactly how animals will be used in the context of the proposed activity.*

Each horse will undergo an evaluation by a incensed veterinarian experienced in equine lameness examination to determine that each participant is biomechanically sound, and has no history of joint disease in the forelimb fetlock joint. All horses will be left unshod for the duration of this study.

Two inch circular reflective markers will be placed on predetermined joint locations on each horse according to protocol. Each horses will be trotted an average of 100 feet in each direction followed by an immediate rest of 2-3 minutes in a straight line on an asphalt surface for each of 3 conditions :(1) treated with a polo wrap (2) treated with a Sports Medicine Boot II and (3) no bandage. At least three trials will be collected for each of the three treatments and should take no more than 10 minutes per treatment. Each trial will include both left and right views.

A polo wrap is made of fleece material and requires no additional underlying bandage material. Sports medicine boots are composed of synthetic material and include three Velcro straps around the third metacarpal bone and a fetlock Velcro strap. The Sports Medicine Boot II® made by Professional's Choice Sports Medicine Products Inc. will be used in this study.

Although the Sports Medicine Boots and Polo wraps are used to protect the lower leg from scraps and bruising but also supports the tendons it is possible to cause damage to the leg and tendon when care is not taken to insure correct pressure is applied. The horses' legs and wraps will be monitored by the project veterinarian and staff to prevent any potential damage.

The polo wraps and sports medicine boots will be wrapped according to protocol provided by Susan Harris in the *United States Pony Clubs Guide to Bandaging Your Horse* as follows: "Applying a polo wrap. Unroll 8 to 10 inches of bandage. Starting at the back of the knee or hock, hold the bandage end diagonally across the outside of the knee or hock, with the end toward the front of the horse. Take one turn around the leg, over the base of the diagonal bandage end. Fold the bandage end downward, over the first wrap and down the back of the flexor tendons. This cushions the tendons and keeps the bandage from slipping. Wrap downward, over the bandage end, keeping each wrap parallel to the last, overlapping half of the width of the bandage and keeping the tension even. At the fetlock joint, drop half the width of the bandage down underneath the joint, bringing it up in front to form an upside-down "V". It should not be loose, but must not be tight enough to restrict movement of the fetlock joint. Wrap upward and finish the bandage on the outside of the cannon bone (not on the tendon, shin or fetlock joint). Most polo wraps have Velcro closures. These should be reinforced with pins or spiral tape.

Putting on boots. Both the boots and the horse's legs should be clean and dry when putting on the boots. Place the boot slightly higher on the leg, and slide it down into position. Fasten the fasteners from top to bottom, and then check to be sure that none is tighter or looser than the others. These boots should be snug and securely fastened, but not tight enough to interfere with the horses, circulation or normal movement. You should be able to slip a finger between the boot and the leg." (Howell Book House: New York, 1997).

Kinematic data will be collected from video images. Linear and angular displacement measurements on the forelimb fetlock will be assessed for each protective/supportive implementation, and for no bandage.

8. A. Select pain/distress category relevant to the use of animals in this study. (See Item 8A of Additional Information at the end of this form.)

C X D _____ E _____

B. If category D or E was chosen in 8A, please complete the following. (See Item 8B of Additional Information at the end of this form.)

1) Database(s) searched or other sources consulted to determine the availability of alternatives.

Database Searched	Date of Search	Years Covered
Medline _____	_____	_____
Agricola _____	_____	_____
CABA _____	_____	_____
Altweb _____	_____	_____
Other (describe) _____	_____	_____

2) Keywords and search strategy used when considering alternatives to the painful or distressful procedure(s).

3) A succinct written narrative based on results of the database search, that will permit the IACUC to readily assess whether the search topics were appropriate and whether the search was sufficiently thorough. This narrative must address reduction, replacement & refinement.

4) If alternatives are available but will not be used, please provide a justification.

5) If pain/distress category E is to be employed, please provide a justification for withholding pain and/or distress relieving drugs.

9. SURGERY:

Will surgery be performed? Yes _____ No X

If yes, please address the following, as applicable:

A. Nonsurvival surgery - Describe all surgical procedures, including surgical preparation. Indicate where surgery will be performed (building and rooms). Identify the person(s) and describe their qualifications for performing the particular surgical procedure(s).

B. Survival surgery - Describe all surgical procedures, including surgical preparation and post-surgical care. Please indicate that aseptic technique will be followed if the procedure is a survival surgical procedure. Indicate where surgery will be performed and what postoperative care will be provided (building and rooms). Identify the person(s) and describe their qualifications for performing the particular surgical procedure(s).

10. Administration of analgesics, anesthetics, tranquilizing drugs, and/or neuromuscular blocking agents (Indicate generic name, dose, route of administration and frequency; if by inhalation, method of scavenging waste anesthetic gases.) N/A

11. Administration of reagents, cells, drugs (other than anesthetics or analgesics), infectious agents, carcinogens, recombinant DNA, etc. (Indicate generic name, dose, route of administration and frequency, anticipated side effects, monitoring protocol.) N/A

12. ASSURANCES:

A. Provide a brief statement to confirm that proposed activities involving animals do not duplicate previous experiments unnecessarily.

A literature search on Medline and Agricola was performed using the keywords horse or equine; bandage or wraps; and there was no literature cited related to this protocol or this experiment.

B. My signature on page 1 of this form certifies that exercise of caged dogs will be accomplished according to the Animal Welfare Act (AWA) or cage size provides adequate space for exercise to meet AWA requirements. Alternatively, explain why an exception should be approved by the IACUC.

N/A

C. Will wild caught or endangered animals be utilized? Yes _____ No X

If Yes, the investigator is responsible for obtaining and maintaining valid permits (if required) for collecting, purchasing, transporting, and holding of these animals. List applicable federal and/or state permit numbers and expiration dates.

13. HAZARDOUS AGENTS

Use of hazardous agents in animals may require approval of the appropriate institutional committee. Contact the Department of Risk Management and Safety (844-4870) for specific information.

Hazardous Agent	Yes	No	Agent	Date of Committee Approval and BUA #
Radioisotopes		X		
Biological Agents		X		
Hazardous Chemicals or Drugs		X		
Recombinant DNA		X		

Describe the practices and procedures required for the safe handling and disposal of contaminated animals and material associated with this study. Also describe methods for removal of radioactive waste and, if applicable, the monitoring of radioactivity.

14. What will be the disposition of the animals at the termination of the project? If euthanasia is to be performed, what will be the method of carcass disposal?

Horses will be returned to the teaching herd. If euthanasia is required, carcasses will be incinerated by the Pathobiology Department, College of Veterinary Medicine, and Auburn University.

15. All protocols must include the method of euthanasia that will be used during the normal course of the protocol or in the event of unforeseen circumstances resulting from illness or injury. Please specify the method, agent, dose, and route of administration. The euthanasia method must be consistent with the AVMA Panel on Euthanasia or justification for deviation should be indicated. This document is available on the Animal Resources website, http://www.auburn.edu/research/vpr/animals/resources/res_index.htm and in the Journal of the American Veterinary Medical Association (Vol. 218, No. 5, Pages 669-696, 2001).

Horses requiring euthanasia will be euthanized by intravenous administration of Beuthanasia Solution® dosed at 10 mL per 100 pounds.



Office of Animal Resources
307 Samford Hall
Auburn University, AL 36849

Telephone: 334-844-5978
Fax: 334-844-4391
oar@auburn.edu

May 25, 2008

MEMORANDUM

TO: Robert Gillette
Clinical Sciences
McAdory Hall

SUBJECT: Protocol Approval, "Effect of Two Bandage Protocols on Equine Fetlock Kinematics"

Your protocol, as received by the Office of Animal Resources on May 1, 2008, was reviewed and approved by the Institutional Animal Care and Use Committee (IACUC) designated member on May 14, 2008 once all training certifications were received. As requested, final approval was granted on May 25, 2008 to coincide with the start date.

The assigned Protocol Review Number (PRN) is **2008-1393** and the protocol will **expire on May 25, 2010**. This protocol was approved for the requested lifespan of 2 years from the starting date of May 25, 2008.

An official copy of the original is being returned (electronically as a PDF) for your files and the original will be maintained in the Office of Animal Resources, 307 Samford Hall. **Please distribute only the final approved version of this protocol, complete with the assigned PRN on the cover sheet, to personnel working with animals on this protocol.**

If you have any questions or need further assistance, please call or contact us via email at oar@auburn.edu

Sincerely,

Dr. Robert Judd
Auburn University IACUC Chairman