UC DAVIS SCHOOL OF VETERINARY MEDICINE . CENTER FOR EQUINE HEALTH

HorseReport

Equine Orthopedics and the Legacy of the Stover Laboratory

FEATURED IN THIS ISSUE

Susan Stover, DVM, PhD, DACVS is a professor in the Department of Surgical and Radiological Sciences and director of the



J.D. Wheat Veterinary Orthopedic Research Laboratory (VORL). After earning her veterinary degree at Washington State University and working in private practice, she completed a surgical residency at UC Davis and a PhD in comparative pathology. She is internationally recognized for her research on the epidemiology, pathogenesis, and biomechanics of repetitive, overuse injuries in equine athletes.

Her wide-ranging research in musculoskeletal injuries in racehorses has contributed to knowledge on detection and prevention of catastrophic breakdowns. She is currently the chair of the Horseracing Integrity and Safety Authority (HISA) Racetrack Safety Standing Committee.

Dr. Stover's celebrated career has been recognized with numerous awards, including the American Veterinary Medical Association's Lifetime Excellence in Research Award, a Founders Award from the American College of Veterinary Surgeons, and induction into the University of Kentucky Equine Research Hall of Fame.

DIRECTOR'S FTTFR

To say that it is an honor to know and work with Dr. Sue Stover would be an understatement. She is a world-renowned expert on equine orthopedics and musculoskeletal injuries and has made significant contributions to these fields over the years. It has been a privilege to witness the breadth of her research program and all that she has accomplished during her career.

Dr. Stover was the Frank J. Milne State of the Art Lecturer at the 2022 American Association of Equine Practitioners Annual Convention, one of the highest honors bestowed

on equine veterinarians. Her presentation highlighted her research on racetrack surfaces, as well as her work to understand fractures and catastrophic injuries in racehorses and sport horses, with a focus on providing knowledge to improve equine welfare. We have captured some of the important points from Dr. Stover's lecture to share with you in this issue.

In addition to being a legendary researcher, Dr. Stover has trained an impressive list of clinicians and researchers who have made their own significant marks in the world of equine veterinary medicine. Her passion and dedication have set an extraordinary example for all of her mentees, especially the women that have chosen careers in equine research.

I am grateful to Dr. Stover for stetting the bar and the standard as high as she did. We can all aim to reach that level with our research and hope to come somewhere close to following her example.

Congratulations on your retirement, Dr. Stover, and thank you for all that you have done to advance equine veterinary knowledge!

Best wishes,

Carrie J. Finno, DVM, Ph.D., Diplomate ACVIM **CEH** Director



HONORING A LOVE FOR THOROUGHBRED HORSES

By Carolyn Sawai

Jonathan Ferrini, a dedicated philanthropist, has made a tremendous impact on advancing animal health at the UC Davis School of Veterinary Medicine since 2005. Most recently, with his bequest, he will establish the Dante and Sharon Ferrini Endowed Chair-honoring his late parents who were Thoroughbred horse enthusiasts.

"Some of my fondest memories growing up are when my parents took my sister and me horseback riding and to the racetracks," Jonathan said. "We enjoyed the competition and the athleticism of these magnificent Thoroughbreds."

He describes his parents as competitive by nature. His father As a world leader setting the pace in equine health, UC Davis was an excellent athlete who lettered in three sports in high is committed to meeting the unique needs of equine athletes school-baseball, basketball and football. His mother enjoyed and investing in the future of equine health through its plans competing in beauty pageants. for the new Equine Performance and Rehabilitation Center. It Dante and Sharon were drawn to experiencing the thrill of will be a cornerstone of the new UC Davis Veterinary Medical horse races. Dante would spend hours studying data and Center-a hub for innovation, healing and discovery.

pouring over charts in a daily horse racing journal as he prepared to wager on races.

The Ferrinis lived in a home adjacent to horse stables and facing the Angeles National Forest in Southern California. Jonathan considers his family fortunate to have had the opportunity to see equine athletes up close.

He credits his mother for inspiring his love of animals. She had a special place in her heart for their family pets. Through the years, Jonathan adopted several homeless dogs and cats and feels that they changed his life forever. In their memory, he established an endowment to create the Belzer, Duke, Midas, Thomas and Willy Ferrini Award for Genetic Researchrecognizing exceptional, promising scientists who will utilize genetics as the foundation of understanding and treating diseases that will help pets like those he cherished.

One final special memory that Jonathan has of his father is their visit to the sportsbook at Caesars Palace in Las Vegas, Nevada. Seated in the large room, Dante had a big smile on his face as he watched several horse races at the same time on the large screens, reminding him of the good times he spent at the race tracks. Jonathan recounted the day as pure nirvana for his father.

Having a high regard for equine athletes, Jonathan believes that they should be treated no differently than human

athletes, who benefit from a better understanding of responding to health issues and, perhaps more importantly, how to prevent them.

"It is my hope that the Dante and Sharon Ferrini Endowed Chair will be instrumental in advancing knowledge in injury prevention and developing innovative treatments to heal injured Thoroughbreds to reduce the need for euthanasia," Jonathan said. "My parents would have been proud to know that this endowment established in their honor will help keep UC Davis at the cutting-edge of veterinary medicine to benefit equine athletes."



Dr. Christina Rohlf

Rohlf's research focused on optimizing the interface between equine locomotion and performance surfaces, with the goal of preventing the most common injuries to tendons and ligaments.

2022 Louis R. Rowan FELLOWSHIP

The California Thoroughbred Foundation Louis R. Rowan Fellowship was awarded to Dr. Christina Rohlf. A recent doctoral graduate in biomedical engineering, Rohlf conducted her research at the J.D. Wheat Veterinary Orthopedic Research Laboratory under the direction of Dr. Susan Stover.

The fellowship, funded by the California Thoroughbred Foundation with financial assistance from the Oak Tree Racing Association, was established in memory of Louis R. Rowan, a founder of the California Thoroughbred Foundation.

Rohlf's research focused on optimizing the interface between equine locomotion and performance surfaces, with the goal of preventing the most common injuries to tendons and ligaments associated with repetitive motions incurred during training and competition. She also obtained limb kinematic data from horses jumping on the same surfaces to determine the effect of surface shear and vertical impact surface properties on limb motion. Using these data, in conjunction with a computer model of equine forelimb locomotion, she is determining the flexor tendon and suspensory ligament strains associated with different surface properties, which are likely related to risk for injury.

"Dr. Rohlf's research exposed the large variation in the mechanical behavior of arena surfaces," said Dr. Stover. "Her results demonstrated that simple categorization of material composition as dirt or synthetic does not capture surface behavior."

Developing a set of standards for arena surface properties designed to minimize tendon and ligament injuries of jumping horses will guide the construction and management of arena surfaces which reduce the risk of injury for horses in training and competition.

In her spare time, Rohlf volunteers as a mentor for the Woodland High School robotics team where she teaches engineering design principles and teamwork. She hopes to continue conducting research to understand and reduce the risk of musculoskeletal injuries of animal athletes.



Dr. Erin Hales

Dr. Erin Hales and Dr. Sarah Shaffer

were named as the recipients of the 2022 James M. Wilson Award. Presented to graduate students or UC Davis veterinary hospital residents, this award recognizes individuals who significantly advance equine health through publication of the year's most outstanding research reports.

Dr. Hales was chosen for her publication entitled, "Postmortem diagnoses of spinal ataxia in 316 horses in California," which was published in the Journal of the American Veterinary Medical Association (2021, 258(12): 1386-93). Dr. Shaffer was honored for her publication, "In vitro motions of the medial and lateral proximal sesamoid bones under mid-stance load conditions are consistent with racehorse fracture configuration," published in the Journal of Biomechanics (2022, 130:110888).

Dr. Hales completed her PhD in animal biology at UC Davis under the mentorship of Dr. Carrie Finno. Her graduate work focused on equine neuroaxonal dystrophy/equine degenerative myeloencephalopathy (eNAD/EDM), an inherited neurodegenerative disorder linked to a vitamin E deficiency. Her research identified cervical vertebral compressive myelopathy (CVCM or wobblers), equine neuroaxonal dystrophy/equine degenerative myeloencephalopathy (eNAD/EDM), and trauma as the leading causes of diagnosable ataxia. This research has helped give veterinarians some insight into which disease may be affecting an ataxic horse in their care.

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Dr. Hales currently uses her knowledge of biological processes and statistics to evaluate and improve personalized medicine in her current role at SomaLogic. She continues to be active in her local equine community and is always looking for ways to bring equine medicine and research together with her current work. "Dr. Hales' publication reflects a

"Dr. Hales' publication reflects a tremendous collaboration between clinicians and pathologists to carefully review medical records of ataxic horses at UC Davis over 12 years and determine the top causes of spinal cord disease in California," said Dr. Finno. "By providing data on which diseases are most likely to occur in which breeds, this study has a significant clinical impact."

Dr. Shaffer completed her PhD in Mechanical and Aerospace Engineering at UC Davis at the J.D. Wheat Veterinary Orthopedic Research Laboratory (VORL) under the supervision of Drs. Susan Stover and David Fyhrie. Her research focused on how proximal sesamoid bone (PSB) fractures develop in racehorses. The PSBs are a pair of

2022 James M. Wilson AWARD

bones in the forelimb of horses and PSB fracture accounts for nearly 50% of racehorse deaths in the United States.

Dr. Shaffer's research helps explain the relationship between PSB fracture, internal biological changes in PSB morphology in response to mechanical loading, and racehorse training and racing history. Dr. Shaffer recently began a new role as a Research Engineer at the Southwest Research Institute.



Dr. Sarah Shaffer and her horse, Beau

"Dr. Shaffer's publication reflects an engineer scientist and accomplished horsewoman making a significant contribution to racehorse welfare," said Dr. Stover. "Building on her work that elucidated the microscopic events leading to PSB fracture, this study discovered biomechanical factors that should be investigated to prevent PSB fracture."

STRAIGHT FROM THE HORSE'S MOUTH: An Interview with Dr. Sue Stover

What led you to a career in veterinary medicine?

My first horse was from the Navajo Indian Reservation in Arizona, which is where our family lived at the time. That experience eventually led to a show horse, which led to my participation in rodeos in college.

During veterinary school at Washington State, I had the opportunity to participate in a few research projects. My mentor suggested that I apply for an internship. At the time, I didn't even know what an internship was! I applied in California, Texas, and a few other places. I was accepted and thought, 'Well, at least I don't have to worry about getting a job."

I loaded my pickup truck and drove down to California going from a very green, lush eastern Washington spring to 105-degree weather and the brown, dry, flat terrain of Davis. I almost turned around and went back! Luckily, it led me from an internship into a residency and meeting my husband (Executive Associate Dean Emeritus John Pascoe).

What led you to study racehorses in particular?

Originally, I was actually interested in colic surgery. However, I received an opportunity from Oak Tree Racing Association to study bucked shins in Thoroughbred racehorses. That really started it all. One of my mentors, Dr. J.D. Wheat, also encouraged me in that direction.

What has been your favorite part of the job?

I love working with horses and enjoy combining that with teams of undergraduate and graduate students, residents and faculty. I love working with teams collaboratively to try to understand and solve problems, and work to prevent injuries in all sport horses.

Can you tell us a story about a challenge in your research that you overcame?

All research is challenging! The cool thing is to be able to overcome the challenges. One challenge in particular that comes to mind is when Keeneland Racetrack in Kentucky called and said, 'We need someone to come measure surfaces.' We managed to put together horses, a trailer, all the equipment, a farrier, staff, and travel arrangements and then Hurricane Katrina hit. The situation helped us understand the benefits of the synthetic surface in hurricane conditions. Putting together equipment, a team, and horses for a project far away that you knew had to succeed was a significant challenge. It was an amazing feeling to actually accomplish it.

In your opinion, what is the most exciting or promising research going on in your field right now?

There are several things, actually. The more that we are learning about surfaces and how they influence risk for injury, but also the technological advances on the horizon that are going to allow us to detect very early mild injuries in horses and appropriately test and rehabilitate them so they can have long careers.

With all of these advances. what do you see for the industry in the next 10 years for orthopedics?

It's going to be much healthier because horses will be healthier. They will have longer careers. Horses will have personalized training and detailed exercise histories. This will benefit both equine and jockey welfare because there will be fewer falls.

I think we're going to see a huge transition, like we've seen in California, to a culture of safety - where everyone is working for the benefit of the horses, the jockeys and everyone will be happier and healthier.

I think in the next 10 years racing will be thriving!

What advice would you give to researchers just starting out in this field?

Be optimistic. Think outside of the box. Follow your dreams. Gather teams around you that you enjoy working with and you will be successful.

What do you love about UC Davis?

UC Davis is a land of opportunities. We have fantastic resources, faculty in the School of Veterinary Medicine, the Department of Biomedical Engineering, and the School of Medicine on the same campus, as well as funding support and bright students. The collaborative opportunities and the synergism are phenomenal. Put that together with amazing people and resources and you have no excuse but to succeed.

Which foundations have supported your research?

The Center for Equine Health has been fundamental to my research program. The Grayson Jockey Club Research Foundation, Inc. has also been a tremendous supporter for a significant number of our racehorse studies. I have been fortunate to obtain funds from various organizations including the McBeth Foundation, Niarchos Foundation, Veterinary Orthopedics Society, Morris Animal Foundation, United States Equestrian Federation, Southern California Equine Foundation, Oak Tree Foundation, and American Quarter Horse Association, among others.

What is next for you?

I'm looking forward to the opportunity to enjoy family, explore the outdoors, and be at home with my husband. I will be continuing my work with the Horse racing Integrity and Safety Authority and doing research because the job is not done!

Be optimistic. Think outside of the box. Follow your dreams. Gather teams around you that you enjoy working with and you will be successful.



Dean Stetter's August video update featured discussions with Dr. Stover, CEH Director Carrie Finno, and others about our researchers' contributions to improving equine health and welfare. Watch "Mondays with Mark" at: https://www.vetmed.ucdavis.edu/ mondays-with-mark-0823.

DR. STOVER'S TOP MYTHS ABOUT EQUINE ORTHOPEDIC INJURIES

Dr. Sue Stover delivered the Frank J. Milne State-of-the-Art Lecture at the American Association of Equine Practitioners (AAEP) Convention in December 2022. The presentation included her top myth busters about equine orthopedic injuries.

Myth: Equine performance sports, such as racing, are invulnerable.

Fact: Equine performance sports are vulnerable.

Horse injury and loss, associated welfare issues, as well as human injuries and financial considerations influence equine sports' social license to operate (i.e. ongoing acceptance by the general public). The veterinary community has an important role in enhancing equine health and welfare through injury prevention and management.

Myth: Thoroughbreds have small, weak bones.

Fact: Thoroughbreds successfully adapt their skeletons to the most recent loading events.

The skeleton is a living structure, and bones have a special ability to repair and regenerate. Bone is made of minerals so it has the strength and stiffness to support the body, but it is also very heavy to carry. Consequently, the skeleton is dynamic; it gets rid of mineral when it does not need it and applies mineral when it does need it.

If we reduce the activity on the bone structure, it develops



Thoroughbred racehorses

holes because the body is removing mineral to make it easier and more efficient for movement. The musculoskeletal system is constantly adapting to sustain increasing or changing loads. The nature of the training determines if the bone gets stronger and adapts, resulting in optimum performance, or whether it gets weaker, is susceptible to injury, and results in poor performance. Reduced exercise intensity can actually lead to increased bone loss. As training advances, the musculoskeletal system must adapt, which reduces stresses and strains, and prevents damage.

Myth: Catastrophic fractures are due to a bad step in a hole. Fact: Catastrophic fractures are due to training or competing on bones with a pre-existing injury.

Severe damage causes bone tissue death. Bone remodeling removes damage and replaces bone, but repair and healing take time. The short period in which an area of damage has been removed results in weakening of the bone. If training and competing continue during this period, there is less bone material available to spread the forces out. As the strains on these areas increase, so does damage to the bone. Continued training on damaged bone leads to stress fractures, and eventually complete fractures.

Myth: Joint fractures are different from stress fractures of long bones. Fact: The only difference between the development of a stress fracture in a long bone and remodeling of a fracture that involves the bone under the cartilage in a joint is that the overlying joint cartilage prevents expansion and the formation of a bone callus.

Pre-existing injury predisposes bones to future fractures. However, if injuries are identified early enough, lesions can be repaired by the same mechanism, regardless of whether the injury is to a long bone or involves the joint.

Myth: Catastrophic musculoskeletal injuries are the cost of doing business.

Fact: Pre-existing injuries that predispose horses to catastrophic fracture develop over weeks to months and provide opportunities for intervention and prevention.

Research has shown that more than 85% of catastrophic injuries are associated with pre-existing injuries. This means that there is an opportunity to intervene and prevent more than 85% of these deaths. This is actually already happening.

California, the New England Region, and New York reported a 40-50% reduction in the catastrophic musculoskeletal injury rate in the last few years. This is due to a number of changes, including an emphasis on a "culture of safety", increased training observations, enhanced collaborations between trainers and veterinarians, reduced medication allowances and withdrawal times for intra-articular corticosteroids.

Myth: It is impossible to prevent injuries. Fact: The risk for injuries can be reduced by managing factors such as hoof conformation and shoeing, as well as training and competing schedules.

Injuries occur when there is an imbalance between the rate of damage formation and the rate of repair and adaptation. Repair is optimized in healthy, young athletes, but healing still requires a minimum amount of time. Healing time can be prolonged, but not shortened. However, we can influence the rate of damage accumulation.

The rate of damage accumulation depends on the magnitude of the load and the rate of load cycles (strides). One of the things that affects load magnitude is hoof conformation. Things like heel angle and toe grabs on shoes can increase the risk for suspensory apparatus injury. The load magnitude is also affected by exercise intensity, which increases ground reaction force.



Horseshoes with toe grabs

Myth: The racetrack surface is the cause of clusters of catastrophic injuries.

Fact: The race surface "may" be a factor, but other factors likely play a role and should be investigated.

The load magnitude is affected by the surface and associated ground reaction forces, which are influenced by moisture, mechanical manipulation (dragging), etc. Surface stiffness affects fetlock angle, with data showing differences in fetlock hyperextension between different surfaces (dirt, synthetic, turf). The hoof is also more stable on some surfaces than others.



Stepping in existing hoofprints increases force on the hoof.

Importantly, we characterize surfaces by their components, but their behavior can differ. Not all synthetic surfaces are alike and not all dirt surfaces are alike. How we manage the surfaces makes a huge difference. Stepping in an existing hoof print in the surface, for example, increases force on the hoof, which increases suspensory ligament strain.

Injuries can be multifactorial. The surface does have a big role, but so do other factors. We will not make a difference until we understand all the factors and attempt to manage them.

Myth: It is impossible to know when individual horses are at risk for injury. Fact: While it is difficult to predict injury in performance horses, there are typical times of high risk that warrant careful consideration.

Injuries are generally related to three scenarios:

1) In general, fractures of the shoulder, humerus, and tibia are due to insufficient conditioning. They typically occur early in training and are related to high increases in training load.

2) Injuries due to deconditioning after rehabilitation occur soon after a return from lay-up. Rehabilitation unloads the skeleton, leading to bone loss, and the bones then experience high increases in load upon return to full training.

3) Injuries due to "over training" occur later in the training program, during high intensity training for a long period without opportunity for recovery. These injuries are more common in older horses.

Relatively little exercise at a new level is required to stimulate adaptation and gain bone mass. Bone responds to the level (magnitude) of work, not the amount of work.

Myth: Injury detection and diagnosis are easy to determine in individual horses.

Fact: Injury detection and diagnosis in individual horses is challenging. It benefits from a thorough medical history, index of suspicion, physical examination, training and behavior observations, and diagnostic imaging.

Research studies detect trends in populations. Applying results to individual horses is challenging. Lameness might not be evident if both legs are affected. However, we know that previous lameness is associated with more severe injury later. Early signs of injury often include changes in demeanor, poor performance, and transient lameness.

It is important to think about when sufficient injury occurred to the skeletal structure. This is a time when high impact loads induce microdamage in a small area, creating mild injury, and possibly pain and lameness. Weeks to months later, as the repair resorbs the microdamage, creating transient bone loss, the horse may be less painful and without obvious lameness, but it is a period that creates high fracture risk later.

Increased collaboration between veterinarians and owners/trainers is essential because knowledge and diagnostics make a significant difference. Research has shown that horses had a lower likelihood of fatal humeral fracture if they were diagnosed by bone scan. Three dimensional imaging methods (computed tomography (CT), positron emission tomography (PET)) can provide a different perspective. Once we recognize what is going on with these horses, they can be managed and they do well.

Myth: Training schedules should be determined based on tradition.

Fact: Knowledge of the processes that occur with skeletal overload and over-repair responses to increases in training intensity or changes in gymnastic events can assist in training individuals to optimize performance without injury.

Training induces cycles of bone damage and repair. Optimally, initial damage is followed by repair and gain in strength. If we wait to increase the load until that adaptation has occurred, there is going to be some microdamage, but it is only going to come down to baseline and then recover and adapt to get to further capacity.

Training that capitalizes on the gain in strength achieves further gain in strength. Training that is too intense further weakens damaged tissues before repair is complete. Loading too soon or too often results in performance decline and injury. Loading too late or too infrequently results in a stagnation in performance. Optimal loading results in adaptation and an increase in performance.

Relatively little exercise is required to maintain bone mass at the current activity level. The work must be relevant to what you are doing, but it does not take a lot of work to maintain it. Additional work is just more damage. Athletes are built with training. The nature of the training influences high versus poor performance.

1) Injuries are the acute manifestation of a chronic process.

2) We can influence the balance between two competing rates damage accumulation and repair.

"It is not easy, but in recent years racing has reduced catastrophic injuries by 40-50%," said Stover. "Think of what we can do if we reduce attrition from mild injuries, extend racehorses' careers, and take away the large economic toll. The industry is already proving that we are capable of doing that."



Standing equine PET scanner.

In summary, skeletal injuries in equine athletes are preventable because:





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JD WHEAT VETERINARY ORTHOPEDIC RESEARCH LABORATORY

The J.D. Wheat Veterinary Orthopedic Research Laboratory at the UC Davis School of Veterinary Medicine is the leader in advancing knowledge of equine musculoskeletal problems. It houses state-of-the-art equipment and fosters a creative environment for basic and clinically applied equine musculoskeletal research. Dr. Susan Stover, a former trainee of Dr. Wheat, has directed faculty work in collaboration with other clinicians and scientists to continue improving our understanding of equine musculoskeletal diseases.

The group has authored multiple publications, trained numerous graduate students, clinical residents, visiting fellows and veterinary students. In addition to presentations at scientific meetings, the researchers have made a number of presentations to industry stakeholders and written articles for horse owners and trainers.

The laboratory derives funding support from competitive granting agencies, research sponsors and industry members. In 1997, a major gift from the Dolly Green Foundation ensured, in perpetuity, the laboratory's future and further increased its competitiveness for sponsored research that directly benefits the equine industry.

The laboratory is focused on factors that can be managed by the industry, thereby facilitating implementation and change for injury prevention. These factors include racing surface and horseshoe interface, training and rehabilitation regimes, and integrative methods of treatment.

Researchers working in the J.D. Wheat Veterinary Orthopedic Laboratory

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