C. WAYNE MCILWRAITH
TRANSLATIONAL
MEDICINE INSTITUTE
COLORADO STATE UNIVERSITY

ORTHOPAEDIC RESEARCH CENTER

Orthopaedic Research Center

Annual Report 2024

MISSION

To investigate the pathogenesis, diagnosis, treatment and prevention of neuro-musculoskeletal disease and injury for the advancement of both animal and human health.

PURPOSE

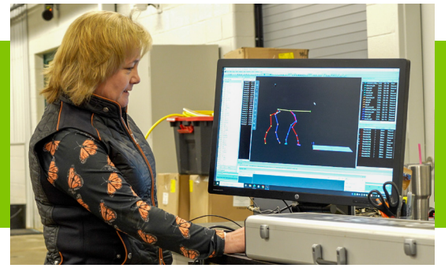
To find holistic solutions to neuro-musculoskeletal problems, with the goal of restoration and optimization of function, repair of injury, and reduction of pain to improve welfare.

PHILOSOPHY

To develop innovative research strategies that elevate the standard and quality of patient care using continued critical assessment of novel findings to guide management of neuro-musculoskeletal diseases.

Dr. Yvette Nout-Lomas and "Mystic Night"

CONTENTS



PROGRAM HIGHLIGHT

Advanced Gait Analytics

READ MORE ON PAGE 36

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ON THE COVER:

Taryn Boxleitner, DVM candidate, with her 10-year-old Quarter horse, "Dash." In 2024, Dash was a quarter finalist at Cheyenne Frontier Days, Monte Vista Pro Rodeo, and Steamboat Pro Rodeo, in addition to winning the Queen Creek, AZ Rodeo. He is also a two-time Mountain States Circuit Finals Qualifier. Dash has benefited from the research within the ORC, receiving chiropractic care from Dr. Melinda Story and tireless veterinary care by Dr. Luke Bass. Dash has also participated in several ORC studies, including microbiome and multifidus muscle studies.

Letter from the DIRECTOR

LAURIE R. GOODRICH, D.V.M., M.S., PH.D.

BARBARA COX ANTHONY UNIVERSITY
CHAIR IN ORTHOPAEDICS

Once again, our annual report brings another year of incredible productivity and impact. The work within this annual report, as in other years, is the culmination of years of ideas, grant writing, collaborating, executing a project and then reporting, presenting and writing results. There is nothing more gratifying than an idea that investigators have poured their heart and soul into come to fruition in a manuscript, but even more importantly one that impacts our patients as well as their human companions. We see this ring especially true when we can prove a treatment effect, as is reported on page 23, where a regenerative medical therapy (umbilical derived mesenchymal stem cells) was used to treat joint pain associated with synovitis and osteoarthritis. Our ORC team has researched regenerative therapies for decades and we have most recently partnered with a company, eQcell, Inc., that is taking this therapy to commercialization. These are the partnerships that help bring therapies from the laboratory to the public, impacting our patients and, ultimately, people. We further report on a productive partnership with Zoetis, Inc. in our clinical trials section of this report on page 22. This trial is comparing a conventional therapy (corticosteroids) to an orthobiologic therapy and will hopefully yield interesting results that inform veterinary and human clinicians of the potential benefits novel treatments derived from the patient's own blood can provide.

On page 36, you will also learn of some of the research that is further developing in artificial intelligence (AI) and advanced analytics, an area that our group has focused on for lameness and biomechanical alterations in gait analysis. With the advent of AI, big data is part of a myriad of various facets of research. AI, like so many other areas of our lives, is transforming research in not only gait analytics but transcriptomics, imaging analysis and almost every research area our team is part of. In 2025, we will begin a search for an AI/advanced analytics specialist within our program to help us continue transforming our research and lead the charge in this exciting area of specialty.

In 2024, we initiated work towards our 5-year strategic plan. Members of the ORC leadership team began to meet, prioritize, and plan for the future of our program. The search for an AI/advanced analytics specialist highlights one of our priorities for the future, along with operational, academic, and program sustainability and excellence. This strategic planning will progress throughout 2025 in which the ORC leadership team will meet, outline and discuss how we grow, how we accomplish our goals, and how we stay nimble in the face of budget uncertainties that academic programs are currently facing nationwide.

Dr. Laurie Goodrich and "Gizmo"

You will also read in the ORC research focus sections on pages 24-35, the textbook chapters, publications, and presentations our principal investigators, postdoctoral fellows, and graduate students have made to disseminate the important work that we do. These are examples of the hard work and outreach that our program yields on an annual basis. It is in the peer reviewed, published science that questions on theories and ideas are proven or disproven. We are always in search of the truth in the most unbiased ways we can accomplish our research. This is what makes our program strong and impactful.

A shining example of this impact is where our group, along with University of Colorado Anschutz and University of Colorado Boulder, was granted an ARPA-H NITRO award. You will read on pages 18-19 about the Advanced Research Projects Agency for Health (ARPA-H), an agency within the U.S. Department of Health and Human Services (HHS), that awarded our CU-CSU team as one of only five groups to receive the Novel Innovations for Tissue Regeneration in Osteoarthritis (NITRO) award. The goal in this award is to create and commercialize injectable and implantable regenerative therapies for osteoarthritis (OA). The ORC program was asked to be part of this award due to our team's ability to provide expertise from the veterinary and basic science perspectives. We are thrilled to partner with our colleagues from CU Boulder and CU Anschutz Medical Campus to bring novel OA therapies to fruition in human medicine. Exciting times ahead!

The pages of this report represent the impact of this dynamic program. As in the last couple annual reports, the images throughout are of our staff, students, graduate students, and clinician scientists, at work and at play, almost always involving horses at the center of what they do. Our mission remains to improve and advance the lives of both animals and people through the research that we perform and apply to our patients. I continue to be honored and humbled by the work that gets done every day within this program. I thank all of you that are friends, partners, and supporters of the ORC. I remain inspired and grateful for all that you do for us. Please feel free to reach out any time, my door is always open to feedback and communication.

With respect and gratitude,

HISTORY

The Orthopaedic Research Center began as a multidisciplinary equine program dedicated to finding methods to treat and prevent equine musculoskeletal disease and injury. Prior to 1984, the program's research was primarily clinical. During this time, many of the techniques for arthroscopic surgery were developed and optimized at CSU, and these techniques were used to treat joint problems more effectively and, further, enable continued athletic function of equine athletes.

We also identified and defined a number of new clinical conditions and documented some of the best methods for diagnosis and treatment for musculoskeletal conditions. The goals of our program are summarized in our research focuses (pages 24-35). As we developed arthroscopic surgical techniques to treat these clinical conditions, we identified limitations in terms of secondary osteoarthritis and articular cartilage loss, and this led into phase two of our program of finding solutions through scientific research. A major goal of the program has always been to find solutions to musculoskeletal problems, especially joint injuries and arthritis. As clinicians, clinician scientists, and/or basic science researchers, we strive to offer the best possible treatment of clinical cases with continual and critical assessment of the results, which are then used to modify treatments and direct the research toward disease prevention. The program's goals are to use state-of-the-art research techniques to find new methods to rehabilitate musculoskeletal injuries, specifically damaged joints, tendons, and bones, to prevent or decrease the occurrence of joint disease and musculoskeletal injuries. We strive to improve methods of early detection, develop better treatments to prevent permanent damage to injured joints, and validate manual therapies and rehabilitation techniques.

The ORC closely collaborates with the Orthopaedic Bioengineering Research Laboratory (OBRL), the Preclinical Surgical Research Laboratory (PSRL), and additional programs in specific research areas, such as metabolomics and immunologic processes in joint disease. Together we make up the Musculoskeletal Research Program which is a Program of Research and Scholarly Excellence (PRSE) at CSU. This designation of PRSE to us was originally granted in 2004 and has been renewed in 2008, 2012, and 2016. The significant collaborations with the College of Engineering and School of Biomedical Engineering, as well as the Department of Health and Exercise Science, has added considerably to our research strengths. In recent years, considerable human-based funding from the Orthopaedic Foundation, National Institutes of Health, Department of Defense, Advanced Research Projects Agency for Health (ARPA-H), and corporate grants have added to our support.

Another significant addition to the ORC has been the development of the equine ambulatory sports medicine and rehabilitation service and an Equine Sports Medicine and Rehabilitation Residency Program. This followed the accreditation of the American College of Veterinary Sports Medicine and Rehabilitation specialty and four of our faculty being made charter diplomates. We quickly developed an equine ACVSMR residency program and have added four diplomates (board-certified in American College of Veterinary Sports Medicine and Rehabilitation, equine specialty) to make us the largest Equine Sports Medicine and Rehabilitation Program in the U.S. This has led to considerable clinical and research advancements in the rapidly emerging field.

In 2016, we achieved funding of $70 million to build the C. Wayne McIlwraith Translational Medicine Institute (TMI). This building came to fruition in 2018, and the Orthopaedic Research Center program moved into the TMI building at that time. The Gail Holmes building has now transitioned to be the Equine Sports Medicine and Rehabilitation Center led by Dr. Melissa King. The TMI is taking us to a new level of orthopedic research in translational musculoskeletal research (as well as allied areas of biologic therapies and stem cell research), doing what we have always done for horses but greatly expanding our efforts in human musculoskeletal disease. This was made possible by a lead gift of $40.5 million from John and Leslie Malone for the building (with an additional $10 million in operating funds), $10 million from CSU, and a $20 million matching gift from Princess Abigail K. Kawānanakoa of Hawaii.

Drs. Katie Seabaugh and Kurt Selberg riding in Iceland

OUR TEAM

FACULTY/PRINCIPAL INVESTIGATORS

Laurie Goodrich - Director of ORC, Barbara Cox Anthony University Chair in Orthopaedics, Professor of Equine Surgery & Lameness

C. Wayne McIlwraith - University Distinguished Professor, Founding Director of ORC, Barbara Cox Anthony University Chair in Orthopaedics Emeritus

Myra Barrett - Associate Professor, Veterinary Diagnostic Imaging

Luke Bass - Associate Professor, Equine Field Service

Erin Contino - Associate Professor, Equine Sports Medicine & Rehabilitation

Felix Duerr - Professor, Small Animal Orthopedic Medicine & Mobility

David Frisbie - Professor, Equine Sports Medicine & Rehabilitation

Fiona Hollinshead - Associate Professor, Small Animal Reproduction

Christopher Kawcak - Iron Rose Ranch Chair, Professor of Equine Surgery & Lameness

Melissa King - Associate Professor, Equine Sports Medicine & Rehabilitation

Lauren Luedke - Assistant Professor, Equine Surgery & Lameness

Brad Nelson - Assistant Professor, Equine Surgery & Lameness

Yvette Nout-Lomas - Associate Professor, Equine Internal Medicine

Lynn Pezzanite - Assistant Professor, Cellular & Molecular Biology

Kelly Santangelo - Associate Professor, Microbiology, Immunology, and Pathology

Katie Seabaugh - Associate Professor, Equine Sports Medicine & Rehabilitation

Kurt Selberg - Associate Professor, Veterinary Diagnostic Imaging

Katie Sikes – Assistant Research Professor, Preclinical Surgical Research Laboratory

Lauren Smanik - Assistant Professor, Equine Emergency & Critical Care

Melinda Story - Leslie A. Malone Presidential Chair, Assistant Professor, Equine Sports Medicine & Rehabilitation

Kelly Zersen - Imaging/ Anesthesia Coordinator

POSTDOCTORAL & GRADUATE STUDENTS

Dylan Ammons - DVM and PhD Candidate, Cellular & Molecular Biology

Charlie Barton -Postdoctoral Fellow, Equine Surgery & Lameness

Taryn Boxleitner - DVM Candidate

Kate Bukovec – Resident and MS Candidate, Equine Sports Medicine & Rehabilitation

Sandro Colla - Postdoctoral Fellow and PhD Candidate, Equine Sports Medicine & Rehabilitation

Giuliana Gabassi - Resident and MS Candidate, Equine Sports Medicine & Rehabilitation

Gabi Kawahisa Piquini - Resident and MS Candidate, Equine Surgery & Lameness

Peter Linde - Postdoctoral Fellow, Cellular & Molecular Biology

Keana McCosh - Resident, Equine Sports Medicine & Rehabilitation

Jaiden Oropallo - PhD Candidate, Biomedical Engineering

Cody Plaisance - MS Candidate and Research Assistant, Cellular & Molecular Biology

Isabella Sabino - DVM Candidate, Cellular & Molecular Biology

Jacob Singer - PhD Candidate and Research Assistant, Cellular & Molecular Biology

Gabby Solum - Resident and MS Candidate, Equine Sports Medicine & Rehabilitation

Riley Thompson - Postdoctoral Fellow, Equine Reproduction

Mikala Vig - Resident and MS Candidate, Equine Sports Medicine & Rehabilitation

Zoe Williams - Postdoctoral Fellow, Cellular & Molecular Biology

Machiel Ysebaert – Resident and MS Candidate, Equine Surgery & Lameness

RESEARCH SCIENTISTS & STAFF

Michelle Alexander - Administrative Assistant, Equine Sports Medicine & Rehabilitation

Sami Badahur - Research Assistant

Becca Cedar - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Lyndah Chow - Research Scientist, Cellular & Molecular Biology

Jennifer Daniels - Research Trials Coordinator

Brigita Fiske – Research Associate

Skyla Hall - Program Coordinator

Renata Impastato - Research Associate, Cellular & Molecular Biology

Natalie Lombard - Surgical Technician

Melinda Meyers - Research Assistant, Equine Reproduction

Meredith Park - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Savanna Parrent - Animal Care Assistant

Nikki Phillips - Laboratory Manager

Kaitlyn Rinker - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Shelby Roberts - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Ryan Shelton - Lead Veterinary Technician

Anne Shirron - Veterinary Technician, Equine Sports Medicine & Rehabilitation

Taylor Winther - Laboratory Assistant

PROGRAM

Dr. Yvette Nout-Lomas (Kellen Bakovich/CVMBS Photo)

OUR IMPACT

AS A PREEMINENT EQUINE AND TRANSLATIONAL ORTHOPEDIC RESEARCH PROGRAM

Both nationally and internationally, the ORC provides critical new findings of significant clinical impact and has been able to attract talented students who wish to pursue careers in orthopedic research. Students choose this program because of its excellent reputation and because of the opportunities they have to be involved in research during their undergraduate and pre-veterinary programs, and veterinary or post-veterinary careers (either while in residencies or post residencies). Many pre-veterinary students have served as volunteers in equine orthopedic research over the past 10 years; this allows students to develop a high level of research expertise during this undergraduate experience. This involvement encourages students to pursue advanced degrees and ultimately research careers. Our program also impacts undergraduate and pre-veterinary education by applying findings from research studies to clinical veterinary medicine.

The breadth of dissemination of information from the ORC is extensive, with information distributed to graduate and undergraduate students in eight departments within five colleges at Colorado State University. Many faculty members from these five colleges who are participants in the Orthopaedic Research Program are internationally recognized; they are therefore able to share research findings worldwide to the academic community, the equine industry, the scientific community, and private biomedical industry. The ORC's extensive collaboration with M.D.s doing research on similar areas of the musculoskeletal system, such as those at CU School of Medicine, Rush Medical Center, Stanford Medical Center, and Steadman Philippon Research Institute, as well as biotechnology companies, with collaboration in multiple NIH and Department of Defense research grants, has significantly impacted the treatment of humans with orthopedic injuries and osteoarthritis. Human medicine, as well as veterinary medicine, has been positively affected by the dissemination of the ORC's findings over the last several decades.

WITHIN THE TRANSLATIONAL MEDICINE INSTITUTE

Faculty and Staff: Over the last 25 years, funding for our orthopedic research and specialized personnel availability has increased dramatically. Until 1994, orthopedic research was being performed by faculty members within the Department of Clinical Sciences. The ORC research team now encompasses 25 full-time faculty members (including three bioengineering faculty) in our program. To support the work of faculty researchers, we now have 18 research associates/research trial coordinators/administrative assistants. We have 18 graduate students in the program as of 2024. To view the full list of ORC members, affiliates, graduate students, and postdoctoral candidates, please visit our website for their bios and publications (www.vetmedbiosci.colostate.edu/orc). Our current funding is approximately $2 million to $4 million annually.

Facilities: In 2002, thanks to generous private donors, most notably Gail Holmes and Herbert Allen, the construction of the Gail Holmes Equine Orthopaedic Research Center and the remodeling of the Orthopaedic Research Laboratories were completed with joint funding from the ORC, School of Biomedical Engineering, and vice president of research at the time, Dr. Tony Frank. At the same time, we built a state-of-the-art equine MRI facility (the first equine-dedicated MRI in the U.S.), funded by Ken and Virginia Atkinson together with a College Chair to fund personnel (that also involved a significant contribution from Jon and Abby Winkelried).

In 2018, with the completion of the C. Wayne McIlwraith Translational Medicine Institute (TMI), the Orthopaedic Research Center program moved into the TMI building

Dr. Brad Nelson and "Hawke"(Kellen Bakovich/CVMBS Photo)

along with the imaging efforts that were initiated in the Gail Holmes building. This allowed access to new surgical facilities, a new gait laboratory, high-speed treadmill, and equine barns for our preclinical investigations to be performed. The gait laboratory and equine barn are part of the ORC program and the building, which houses both the gait lab and the new barn, is called the Equine Performance Analysis Facility.

The Gail Holmes building that once housed the ORC program is now dedicated to the Equine Sports Medicine and Rehabilitation (ESMR) Program, and the Orthopaedic Research Laboratories have received further renovation and are largely occupied by the OBRL. This space is shared, to some extent, with the ORC. These facility updates have greatly contributed to the larger vision of the ORC mission of impacting not only horses but also people through translational research.

Endowed Chairs: The ORC has three, $3 million University Endowed Chairs; the Barbara Cox Anthony University Chair in Orthopaedics (held by Dr. Laurie Goodrich); Iron Rose Ranch Chair (held by Dr. Chris Kawcak); and the Abigail K. Kawānanakoa Chair in Alternative Medicine (search for position is currently underway). We also have a $1.5 million Chair in Musculoskeletal Imaging from the estate of Kenneth and Virginia Atkinson and, most recently, a $6 million Presidential Endowed Chair from John and Leslie Malone named the Leslie Malone Presidential Chair in Equine Sports Medicine that Dr. Mindy Story now holds. The funding also supports one of our equine sports medicine residencies. We continue to pursue endowed funding to make all our positions permanent.

Equine Ambulatory Sports Medicine and Rehabilitation Service: A new veterinary specialty, the American College of Veterinary Sports Medicine and Rehabilitation, was accredited by the American Veterinary Medical Association May 2009. There were 27 charter diplomates established by a nomination and Delphi election system. Four of our faculty, Drs. C. Wayne McIlwraith, Kevin Haussler, Chris Kawcak, and David Frisbie, were made charter diplomates of the new college. An equine ambulatory sports medicine service was initiated in 2010 from within the ORC, and has now grown to the following members; Drs. Kawcak, Frisbie, Haussler, Melissa King, Mindy Story, Erin Contino, and Katie Seabaugh. There are now six clinical technicians/administrative assistants aiding in this service offering state-of-the-art expertise in equine ambulatory neuromusculoskeletal problems in athletic horses. The service has three sports medicine residents and has graduated 13 residents from the three-year program in equine sports medicine and rehabilitation.

Unrestricted Funding from Donors, Foundations, and Industry Partners: We have continued with good support and have been further able to increase faculty and staff positions, despite the COVID-19 pandemic that caused significant shutdowns, delays, and reorganization efforts. Donor support has been critical to our continued operation and growth since the program's inception. In 2022, Ms. Gail Holmes donated $200,000 towards a residency program in ESMR, allowing the continued support of a resident for 3 years. Additional residency support from industry partners like Platinum Performance and Dechra have made it possible to train more up and coming ESMR veterinary specialists. Our team came through this dark time with dedication and resolve, and has carried on our mission though expanded translational efforts.

DONORS

With grateful acknowledgment to those who are so critical to the continued success of our program

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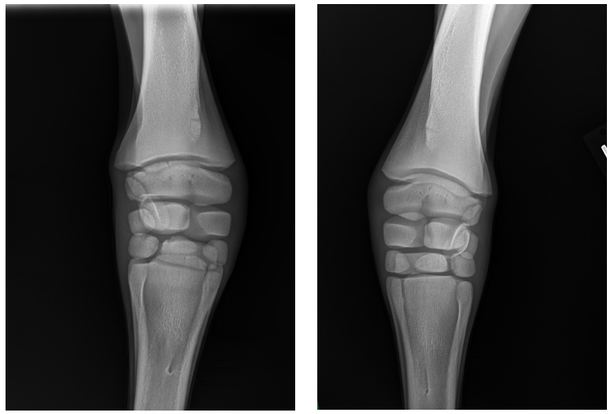
TRUE DEDICATION

HORSE LOVERS HONOR EQUINE ATHLETES, CSU CARE

Hank and Karen True are life-long horse advocates and cutting horse competitors. In partnership with several trainers, the True horses have made a name for themselves in the cutting horse rodeo circuit the last two decades. The Trues own and operate two ranches, one in Wyoming and the other in Arizona, making Colorado State University and the Johnson Family Equine Hospital (JFEH) a convenient, helpful and centralized hospital for their horse care needs. The Trues have been bringing their horses to CSU for years, utilizing equine services at the JFEH and the Equine Reproduction Laboratory (ERL).



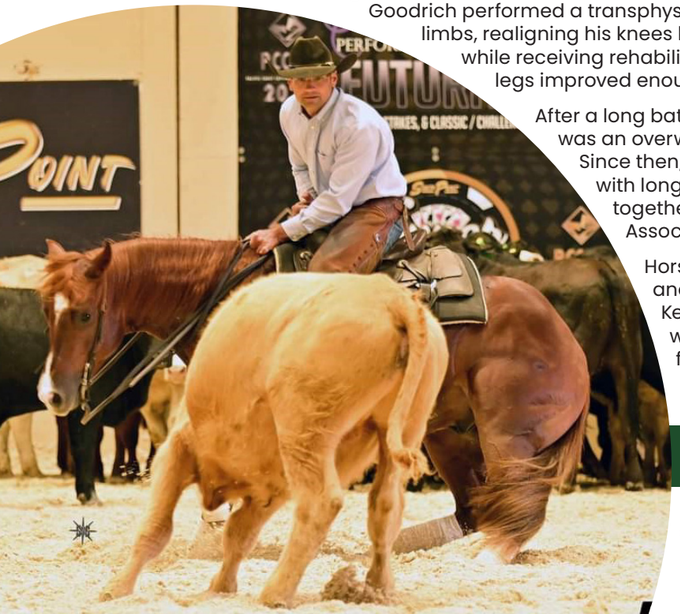
Dust Cutter's radiographs revealing bilateral carpal valgus.

One of the True's favorite mares, Play Bling, was a successful cutting horse competitor, having won a lifetime earning of $55,000. After an impressive career, it was time for Play Bling's retirement in 2018. The Trues worked with the ERL to assist Play Bling in pregnancies. She went on to carry four foals, all of which now participate in the competitive cutting horse rodeo circuit as well. Play Bling's final foal was born in 2020 and is an exciting, standout example of expertise within CSU that has allowed him to thrive and win; his name is Dust Cutter (Smooth As A Cat x Play Bling).

Dust Cutter came to CSU as a foal and was diagnosed with bilateral carpal valgus, a misalignment of his front knees, causing them to point inward. In 2020 when Dust Cutter was only a few months old, Dr. Laurie Goodrich performed a transphyseal bridge, of implants and screws, on both front limbs, realigning his knees back into a healthy position. Dust Cutter stayed at CSU while receiving rehabilitation care as well as corrective hoof trims until his legs improved enough to start training.

After a long battle with angular limb deformity, Dust Cutter's training was an overwhelming success, turning him into a genuine athlete. Since then, Dust Cutter has gone on to win cutting competitions with long-time trainer, Kenny Platt (pictured). Most recently, together they won the September 2024 Pacific Coast Cutting Association (PCCHA) Futurity Championship.

Horses, especially those who are athletes, require large and dedicated care teams with a range of specialties. Kenny Platt, along with other trainers and riders, have worked with the Trues and their horses for years, fostering close connections with obvious success.



Kenny Platt and Dust Cutter at the 2024 PCCHA

Kenny Platt and family after winning the 2024 PCCHA Futurity Championship with Dust Cutter.

The continued partnership between the Trues and CSU equine veterinarians, in particular, Drs. Laurie Goodrich and Pat McCue (ERL), reaffirms CSU's equine program pillar missions of providing exceptional horse care based on years of research, not only while the horses are in our care, but after they have returned to their home pastures.

Hank and Karen True's mutual love of horses has created a passionate involvement in national stock shows and rodeo competitions, spanning decades. In more recent years, Hank has served as the National Western Stock Show Director as well as the College National Finals Rodeo Chair. The couple's passion for horse care and education naturally steered them toward philanthropic efforts with the creation of the Verdad Foundation. Hank and Karen have been consistent donors and enthusiastic supporters of the Orthopaedic Research Center because our research directly correlates back to optimized orthopedic care for horses resulting in healthy thriving athletes. Hank believes that "the advancement of science that is being performed at the Orthopaedic Research Center is so adaptable and applicable, the ORC contributes to advancing health throughout the world." The ORC is exceptionally proud and grateful to have Hank and Karen as partners in our mission.

GIVING OPPORTUNITIES

The Orthopaedic Research Center at Colorado State University continues its mission daily to investigate the pathogenesis, diagnosis, treatment, and prevention of musculoskeletal disease and injury for the betterment of both animals and humans. Groundbreaking advancements in orthopaedic treatments are a result of support and partnerships, and the ORC is made better daily by the philanthropic generosity of many over the years. Thank you to all who support, and to all who will in the future.

If you have questions about giving opportunities, please contact Assistant Vice President of Advancement, Sarah Schmidt:

cvmbs-giving@colostate.edu

Hank and Karen True

COMPLETING *the* CYCLE

EQUINE REHAB SERVICE PROVIDES CUSTOMIZED RECOVERY FOR INJURED HORSES

STORY : Bekah Lamb
PHOTOS : Bekah Lamb, Dane Aragon
Colorado State University

It's 10 a.m. and Dr. Melissa King is overseeing an underwater treadmill treatment for Dallas, an equine patient in the CSU Orthopaedic Research Center. While she watches the horse run through its paces in the water, she thinks about the teamwork that makes this kind of individual attention possible.

"It takes a village for the extensive nature at which we have horses undergoing rehab here," King said.

The rehab "village" consists of head technician Anne Shirron, student hourlies Madison Zinni, Samantha Moore, Samantha Humphries, Grace Falkner, Kylie Yancey, and Halley Moak, administrative support coordinator Michelle Alexander, and sports medicine residents Mikala Vig, Keana McCosh, Giuliana Gabassi and Tabitha Sternberg-Allen.

"It's the day-to-day work that these guys do – they are invested in the horses' welfare just as much as the owner and just as much as I am," King said. "They work really hard and tirelessly day in and day out to get these horses back to performance."

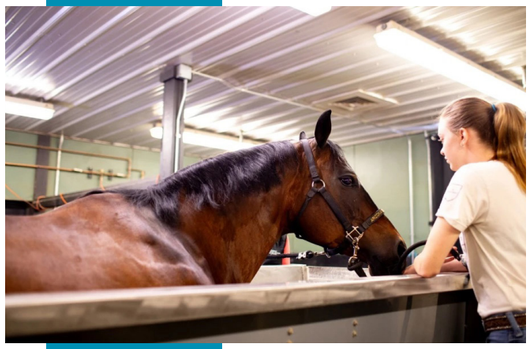
King and her team work with the horses five to six times a day on modality applications, core exercises, range of motion and stretches. In addition to the underwater treadmill, treatments can include therapies like proprioceptive balance pads, laser therapy and a current study of the use of wearable technologies to detect and prevent injury.

CSU's Equine Sports Medicine and Rehabilitation service is unique due it its proximity to the university's veterinary teaching hospital and its equine specialists.

"Having an in-house rehab center means we can complete the cycle," King said. "Your horse comes in for a lameness exam, it gets worked up, it may need surgery. After surgery it can come here for rehab," King said.

They can host up to five horses, which could be considered small compared to other facilities, but manager Anne Shiron explains this, along with their expertise, allows an in-depth and unique approach for every horse.

Michelle Alexander, who often is the first contact for clients, said that because King is a leader in rehab, she gets calls from all over the globe. She said that clients are often surprised by the sheer number of modalities they offer.



"I think a lot of people try to equate it with human rehab and we have so much at our disposal and then with Dr. King running it, and the absolute brilliance that she brings," Alexander said.

And where there are no treatments available for her patients, Shiron said she's seen King create new ones utilizing creative resources. She says this speaks to the amount of care King has for her patients, "she loves them to the point of invention."

Some of the horses they see are in competitive disciplines such as dressage, hunters and jumpers, cutting, and team pinning.

King says that one of the most rewarding parts of her job is getting updates from clients after their horses have completed the program.

Sometimes clients will send videos or pictures of their horses with their win ribbons, which demonstrates "we took a horse with a significant level of injury and now they are back or even at a higher level of performance," King explained.

King enjoys watching residents have those "aha" moments in the field, and she appreciates the camaraderie they can establish within their small team.

Because their patients can be there for extensive periods of time, the team says it's not uncommon to get attached.

"They are my therapy for sure," King said. "They are very peaceful, gentle, creatures, and so you kind of feed of their energy."

"There are times when I'll be in the back stall, and I'll be having a conversation. It's one side but it makes me feel better. And my residents or my technician will walk in and be like 'are you talking to me?' and I'll be like 'no I'm actually therapeutically releasing to the horse,'" King said.

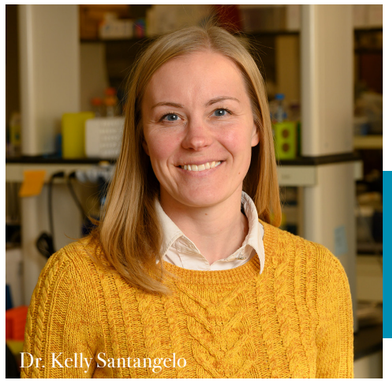
"I get to be the fun aunt because I don't make them work," Alexander laughs. "I just go out there and give them scratches and love and give them an apple or a cookie."

Head technician Shiron says she learns patience from her patients: "I feel like they (the horses) can teach you so much patience if you let them. And they also teach you how to slow down and really appreciate what you're doing. Because I feel like we're so go-go-go with everything we do. And sometimes you know, the slower you go, the faster you end up going."

FINDING *a* CURE

JOINTS THAT COULD HEAL THEMSELVES? RESEARCHERS COULD GET THERE IN FIVE YEARS

STORY : CU Boulder Today


Dr. Kelly Santangelo


Dr. Laurie Goodrich

Imagine a day when joints could heal themselves.

At the first inkling of a creaky knee, patients could get a single shot in the joint that would not only stop their cartilage and bone from eroding, but kick start its regrowth. In more advanced cases, that shot might also deliver a biomaterial repair kit to patch holes in tissue. If multiple joints ached, an annual IV infusion could ferry regenerating therapies to all of them at once.

This may seem like a dream to the 32.5 million people who suffer from osteoarthritis. Last year, the Advanced Research Projects Agency for Health (ARPA-H) awarded up to $39 million to a University of Colorado Boulder-led team of scientists to work toward making it a reality.

The Novel Innovations for Tissue Regeneration in Osteoarthritis (NITRO) program, managed by Dr. Ross Uhrich, was the first launched by ARPA-H, a federal agency to support "high-impact solutions to society's most challenging health problems."

With the cash infusion, a dream team of engineers, medical scientists and veterinarians from CU Boulder, the CU Anschutz Medical Campus and Colorado State University can make an aggressive final push toward a goal many have spent their entire careers pursuing.

"Within five years, our goal is to develop a suite of non-invasive therapies that can end osteoarthritis," said project leader and Principal Investigator Stephanie Bryant, PhD, professor in the Department of Chemical and Biological Engineering, Materials Science and Engineering, and the BioFrontiers Institute at CU Boulder. "It could be an absolute game-changer for patients."

An epidemic without a cure

Osteoarthritis is the third most common disease in the U.S. and affects roughly one in six people over age 30 worldwide.

The disease causes cartilage—the buffering tissue that keeps bones from grinding together—to decay. Over time, bone is damaged too, which reshapes the joint and results in movement becoming painful.

Age and obesity increase risk, and rates are on the rise as the U.S. population ages and grows more sedentary. At present, patients are generally limited to two options: Treat the pain and, when that is no longer adequate, surgically replace the joint. There is no cure.

"To truly address osteoarthritis, you have to get at both the biology and the structural problem," said co-Principal Investigator Michael Zuscik, PhD, professor and research vice chair in the Department of Orthopedics at the Anschutz Medical Campus. "This unique Colorado dream team we have put together has the multidisciplinary expertise, and now the resources, to tackle both at once. We can approach curing the disease like never before."

Zuscik spent 15 years developing and testing a drug that addresses the biology, nudging both cartilage and bone cells to produce proteins needed to rebuild. While promising, it must be injected every day.

Meantime, Bryant, a materials scientist, has worked for 26 years to develop three-dimensional gel-like biomaterials that can slip into the cracks of torn cartilage or worn bone, providing supportive scaffolding — like the joists of a new building—for the body's own cells to migrate to.

And scientists at CSU have been working for years to perfect gene therapy techniques aimed at controlling inflammation and hastening cartilage healing.

(Pictured left) Kelly Santangelo, DVM, PhD, associate professor of microbiology, immunology, and pathology and Laurie Goodrich, DVM PhD, equine surgeon/clinician scientist and director of the Orthopaedic Research Center, are leading the CSU team in this multi-institutional effort. Their expertise in osteoarthritis across a variety of animal species, as well as companion animals helps lead the way in breakthroughs the collaborative Colorado teams within ARPA-H NITRO are making to translate to humans.

The team now faces an engineering challenge – to devise methods to deliver these technologies to the body together, in a way that provides lasting benefit and treats multiple joints at once if needed.

A one-shot medical breakthrough

To that end, the team is developing nanoparticles that could be administered intravenously, serving as Trojan horses that migrate to inflamed sites and deliver a regenerative medicine cocktail that enables joints to heal.

The team hopes to ultimately commercialize three innovations: a healing shot; an injury-patching hydrogel; and an annual infusion for systemically treating osteoarthritis.

When it's time for trials, co-Principal Investigator Laurie Goodrich, DVM PhD, a veterinary clinician scientist and director of the Orthopaedic Research Center at CSU's Translational Medicine Institute, will lead the charge in animals.

"CSU's expertise in veterinary medicine will play a crucial role in helping to move this science to the next step," said Goodrich. "It's humbling to be a part of it."

Within 3.5 years, the team hopes to begin conducting trials in human patients.

However, it's not enough to simply develop such treatments, said Co-Principal Investigator Karin Payne, PhD, associate professor of orthopedics at CU Anschutz.

"At the core of this, the goal is to develop a therapy that's going to be available to all Americans, not just a privileged few," Payne said, noting that researchers will include a demographically diverse group of study participants and minimize cost to make the treatments as affordable as possible.


NITRO Colorado Team Leadership

Early collaborations between team members were catalyzed by AB Nexus, which provides internal funding and resources to support partnerships between CU Boulder and CU Anschutz.

The Colorado team is one of five performer teams to receive an award in the NITRO program.

"This is one of the most debilitating diseases there is and leads to people not being able to work or do the things they love," Bryant said. "The resulting lack of exercise increases the risk of other problems like heart disease. For us to have a chance to improve people's lives – it's the opportunity of a lifetime."

This research was, in part, funded by the Advanced Research Projects Agency for Health (ARPA-H). The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the United States Government.

DRIVING REAL-WORLD SOCIAL AND ECONOMIC IMPACT THROUGH FUTURE TREATMENT IN ANIMALS AND HUMANS

STORY & PHOTO: CSU STRATA Staff

Researchers at Colorado State University are working to improve the day-to-day lives of people and animals suffering from osteoarthritis. Osteoarthritis is a degenerative joint condition that causes pain, swelling, and stiffness, affecting a person's ability to move freely. The condition limits movement and activity for more than 500 million people worldwide and is cited as the leading cause of euthanasia in dogs. Laurie Goodrich (left), professor of equine surgery and Director of the Orthopaedic Research Center, Felix Duerr (top right), professor of small animal orthopedics in the CSU Department of Clinical Sciences, Dr Lester Suarez (bottom right), CSU affiliate faculty member, and Jaiden Oropallo (above right), Bioengineering PhD student in the CSU School of Biomedical Engineering, are working to develop new treatment options for osteoarthritis through gene therapy—the reprogramming of cells—in companion animals.

Dr. Felix Duerr

Current osteoarthritis treatments focus primarily on pain relief. Goodrich, Duerr and Oropallo want to address the fundamental issue behind the disease—inflammation—using gene therapy to produce protein-based therapeutics. Protein-based therapeutics describes medicines that use genetically engineered versions of naturally occurring animal or human proteins. Their team is working to develop and engineer specific proteins to enhance their therapeutic performance and effectiveness in treatment.

Dr. Lester Suarez

As a translational scientist, Goodrich and Duerr seek to develop medical solutions that benefit both animals and people. After perfecting their treatment in the laboratory, the team will move to a larger clinical trial to test the efficacy in canine patients with naturally-occurring osteoarthritis. Their goal is to develop a startup company around the technology to drive real-world social and economic impact through future treatment in animals and, eventually, humans.

In 2023, Goodrich and Oropallo received funding from the Advanced Industries Proof of Concept Grant Program to advance their research. "This funding has allowed us to really start the project. Before this, we were not able to design as many protein variants as we wanted, and we weren't able to test them as efficiently as we hoped, so this funding has helped us lay the groundwork for our preclinical and clinical trials that will be starting in the future," said Oropallo.

CSU STRATA GRANT PROGRAM

Advanced Industries funds are provided to CSU through the Colorado Office of Economic Development and International Trade with the goal of accelerating commercialization of innovations with high potential for creating economic impact in the state of Colorado.

Learn more about the grant program at:

csustrata.org/technology-transfer/ai-poc-grant/

Dr. Lynn Pezzanite

Dr. Charlie Barton – 1. Best Clinical Resident Award, American Association of Veterinary Clinicans; 2. Mark Bloomberg Resident Research Award

Jen Daniels – SPOT Award, CSU Department of Clinical Sciences

Brigita Fiske – SPOT Award, CSU Department of Clinical Sciences

Dr. Melissa King - Top 5 Finalist for the Veterinary Rehabilitation Therapist Award, International Association of Veterinary Rehabilitation and Physical Therapy

Natalie Lombard – SPOT Award, CSU Department of Clinical Sciences

Dr. Brad Nelson – Clinical Research Faculty Award, CSU College of Veterinary Medicine and Biomedical Sciences

Jaiden Oropallo – Best Teaching Assistant, CSU Biomedical Engineering

Dr. Lynn Pezzanite – 1. Zoetis Veterinary Research Award, CSU College of Veterinary Medicine and Biomedical Sciences; 2. Basic Research Award (Assistant Professor) – CSU College of Veterinary Medicine and Biomedical Sciences

Nikki Phillips – SPOT Award, CSU Department of Clinical Sciences

Dr. Mindy Story – Leslie A. Malone Chair in Equine Sports Medicine and Rehabilitation

DR. C. WAYNE MCILWRAITH RECEIVES NEW ZEALAND ROYAL HONOUR

Dr. C. Wayne McIlwraith (right) has been appointed as an Officer of the New Zealand Order of Merit in recognition of his services to veterinary medicine and the equine industry

New Zealand has a system of Royal Honours which are awarded twice yearly by their Governor General, acting on behalf of King Charles III, with the purpose of recognizing those who have served and achieved. There are various ranks for the New Zealand Order of Merit and Dr. McIlwraith's rank of Officer is awarded to those who "in any field have rendered meritorious service to the Crown and nation or who have become distinguished by their eminence, talents, contributions, or other merits."

Dr. McIlwraith has achieved and contributed a tremendous amount to veterinary orthopedics and translational medicine, including bringing arthroscopic surgical techniques to the field of equine medicine. In his 40+ years at CSU and in private practice, he has made a monumental impact on horses, owners, residents, clinicians, and researchers, and has touched innumerable lives, many of which he will never know. He has forever moved the needle on orthopedics. He is a true legend and a gift to our profession.

CLINICAL Trials

ABOUT CLINICAL TRIALS

Clinical trials are research studies that help medical professionals improve the detection and treatment of illnesses. Our clinical trials program enrolls client-owned horses to evaluate the effectiveness of new drugs such as blood-derived biologics, mesenchymal stem cells therapies, and gene therapy techniques to treat orthopedic diseases. Many of the musculoskeletal treatments used in horses today are the result of pre-clinical trials within the Orthopaedic Research Center, specifically the use of corticosteroids and novel biologic therapies. We learn valuable information from every patient, and we use this information to improve their care as well as the care of future patients, both horses and people.

Each clinical trial has specific eligibility criteria that need to be fulfilled for a horse to participate, and these vary among studies. Some clinical trials are designed for horses with a particular diagnosis of orthopedic disease (i.e. osteoarthritis), while others are open to horses with a variety of orthopedic abnormalities. In general, to qualify for Colorado State University's trials, horses need to have a specific musculoskeletal problem that is diagnosed by their veterinarian or one of veterinarians, and are otherwise healthy. Owners also must be willing to comply with study protocols and commit to coming into the clinic for the visits that are required by the trial.

WHY CLINICAL TRIALS ARE IMPORTANT

With help from equine participants, clinical trials help doctors in the medical and veterinary fields discover disease prevention methods and find new ways to improve detection, diagnosis, and treatment of animal illnesses, all while enhancing the quality of care each patient receives. The clinical trials within the ORC contribute to research that discovers better treatments for horses and people with orthopedic disease, and provide an alternative when standard treatment options are no longer effective. Our clinical trials also explore new therapies to treat disease that is unlikely to have a significant response to standard treatment. Finally, clinical trials offer financial assistance for potentially life-saving treatments that clients otherwise may not be able to afford.

Freeze-Dried Conditioned Serum Clinical Trial

Dr. Erin Contino (left) and Dr. David Frisbie

"Evaluation of the safety and efficacy of intra-articular allogeneic freeze-dried conditioned serum (FDCS) in horses with lameness regionalized to the distal interphalangeal joints."

This clinical trial will be starting soon and aims to compare freeze dried allogenic conditioned serum (conditioned serum is also referred to as IRAP) to a placebo treatment. Horses with naturally occurring lameness isolated to the front feet will be eligible for enrollment.

Prostride Clinical Trial

Dr. Erin Contino and Dr. Laurie Goodrich

Sponsored by: Zoetis

"Evaluation of autologous protein solution (Prostride) as an intra-articular anti-inflammatory therapy for adult horses."

This double blinded clinical trial is currently enrolling horses with naturally occuring lameness of the stifle (specifically the medial femorotibial joint). Horses are randomly divided into two groups and treated with either Prostride or corticosteroid/hyaluronan and followed over 6 months to assess response to treatment. Referring DVMs and clients suspecting their horses have pain and lameness originating in the stifle are encouraged to enroll by emailing Dr. Erin Contino (erin.contino@colostate.edu) and Dr. Laurie Goodrich (laurie.goodrich@colostate.edu).

FOR MORE INFORMATION ON STUDY PROTOCOLS, ELIGIBILITY, AND OWNER RESPONSIBILITIES VISIT:
VETMEDBIOSCI.COLOSTATE.EDU/ORC/RESEARCH/CLINICAL-TRIALS

TRIAL FINDINGS

RECENTLY COMPLETED STUDY DETERMINES MESENCHYMAL STROMAL CELLS SIGNIFICANTLY DECREASE PAIN AND LAMENESS IN THE CARPUS OR FETLOCK

K. Seabaugh, S. Rao, J. Koenig, L. Pezzanite, S. Dow, T. Koch, K. Russell, S. Mehrpouyan, A. Alizadeh, L. Goodrich

Sponsored by: eQcell, Inc

Synovitis is present before and during osteoarthritis in horses and can result in performance-limiting lameness. Twenty-four horses with lameness localized to the metacarpo-/metatarsophalangeal joint or a single joint of the carpus were enrolled in this study. We evaluated the response of intra-articular injection with 10 million activated (aMSC) or non-activated (naMSC) allogeneic equine umbilical cord blood-derived mesenchymal stromal cells (MSCs). Subjective and objective lameness was assessed on Days 0, 1, 21, and 42. The treatment injection was randomly assigned and performed following the baseline assessment on Day 0. naMSC-treated horses had straight-line lameness scores that were significantly lower on Day 21 (1.0 ± 1.15) and Day 42 (1.13 ± 1.00) than on Day 0 ($p = 0.0098$ and $p = 0.0418$, respectively). aMSC-treated horses had straight-line lameness scores that were significantly lower on Day 21 (0.96 ± 1.03) and Day 42 (0.79 ± 1.05) than on Day 0 ($p = 0.0011$ and $p < 0.0001$, respectively). There was no significant difference between the treatment groups for any parameter at any timepoint. In conclusion, both aMSC and naMSC allogeneic MSCs resulted in significantly improved subjective lameness scores in horses when compared to baseline lameness scores.

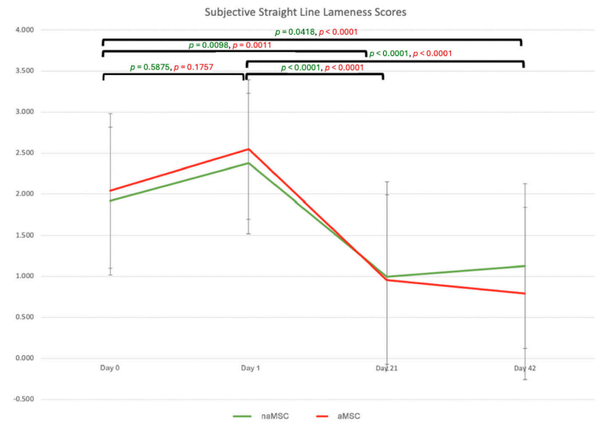


Figure 1 (left): Mean subjective lameness scores for straight-line assessment. Subjective and objective lameness was assessed on Days 0, 1, 21, and 42. Lameness was graded on a 0-5 scale. 0 = sound horse with no lameness present, 5 = non-weight bearing (partially or fully) at walk.

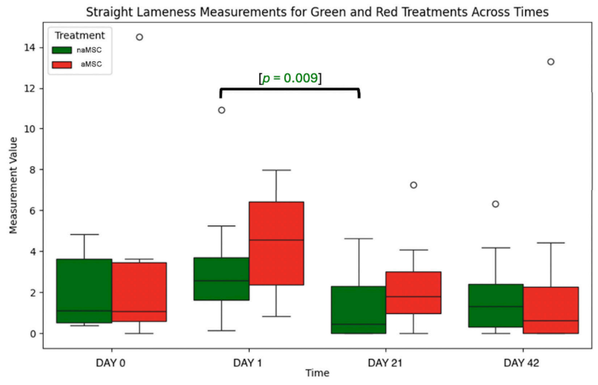


Figure 2 (right): Objective lameness measurements on a straight line across time. Circles represent outliers in the data set. The only significant difference identified in the objective lameness data was in naMSC-treated horses showing lower lameness scores on Day 21 than on Day 1 ($p=0.009$).

FOR THE COMPLETE STUDY, VISIT: HTTPS://COL.ST/BGIUB

focus *one*

PROMOTE THE REPAIR AND OPTIMAL HEALTH OF NEURO-MUSCULOSKELETAL TISSUES

a. Orthobiologic therapies
b. Pharmacologics
c. Surgical techniques
d. Physiotherapy, rehabilitation, and conditioning

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Pezzanite L. Clinical insights: Regenerative therapies in equine practice: Top 10 EVJ papers 2019-2024. Equine Veterinary Journal. 2024 September; 56(5):824-831. PMID: 39113179.

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Williams Z, Pezzanite L, Hendrickson D. Review of skin grafting in equine wounds: indications and techniques. Equine Veterinary Education. 2024 September; 36(9):484-493. Epub February. PMID: 39246829.

Dr. Erin Contino and "Handsome Ransom"

Winston S, Pezzanite L, Dow S, McGilvray K. Parametric computational modeling of melt electrowritten scaffolds; Predicting the cellular micromechanical environment for gradient tissue engineering in rotator cuff repair. International Journal of Bioprinting. 2024 November: 11(1):347-362.

RESEARCH ABSTRACTS, PRESENTATIONS, PROCEEDINGS

Ammons D, Chow L, Goodrich L, Williams Z, Dow S, Stoneback J, Pezzanite L. Longitudinal single-cell RNA sequencing of equine synovial fluid following osteochondral chip fragmentation reveals early osteoarthritic changes. University of Colorado 6th Annual Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship. Poster.

Ammons D, Chow L, Larson B, Bass L, Goodrich L, Dow S, Pezzanite L. Transcriptomic response to osteoarthritis using single-cell RNA sequencing in an equine model. Orthopedic Research Society. Poster.

Barton C, Hector R, Hendrickson D, Kawcak C, Nelson B, Goodrich L. Does perioperative fasting affect manure output and colic following general anesthesia? American Association of Equine Practitioners. Proceedings: p. 503-504.

Bass, L. Equine field surgery. CSU Annual Conference. Podium.

Bass, L. Field surgery and ERs. Mid Coast Veterinary Medical Association. Podium.

Colla S, Johnson J, McGilvray K, Zanotto G, Seabaugh K. Alterations in equine middle phalanx angle following alterations to the palmar angles – a descriptive cadaveric study. American College of Veterinary Sports Medicine and Rehabilitation Annual Conference. Podium.

Contino E. a. Joint therapies including orthobiologics: What, when and why?; b. Joint injection wetlab. American Association of Equine Practitioner's Focus on Field Medicine. Instructor.

Contino E. a. Orthobiologic treatment of musculoskeletal disease; b. Managing suspensory disease: treatment and rehabilitation; c. Treatment and rehabilitation of neck, back and SI dysfunction; d. Orthobiologics Table Talk. 39th World Veterinary Association Congress. Podium.

Contino E. a. Orthobiologics: How to make sense of the alphabet soup; b. Management of neck and back pain in horses. American Association of Equine Practitioner's 25th Resort Symposium. Podium.

Contino E. a. Joint therapies: Corticosteroids, orthobiologics and beyond; Part 1; b. Joint therapies: Corticosteroids, orthobiologics and beyond; Part 2. Colorado Veterinary Medical Association Annual Convention. Podium.

Goodrich L. a. An update on biologics for joint disease: Where do we currently stand?; b. Interpretation of lameness with use of sedation: Does it really change things? Zoetis. Invited Speaker.

Goodrich L. Equine open fractures have significantly higher infection rate than any other species. AO Vet Lecture. Webinar.
Goodrich L. Complications of Fracture Repair. Vet PD. Webinar.

Goodrich L. a. Arthroscopic surgery of the carpus (lab); b. Arthroscopic surgery of the tarsocrural joint (lab); c. Arthroscopic surgery of the fetlock joints (lab); d. Basic Arthroscopic Techniques. CSU Continuing Education Basic Course. Instructor.

Goodrich L. a. Management of orthopedic infection; b. Surgical approach and plate application of simple olecranon fractures; c. Postoperative considerations and management after articular fracture repair. AO North America Principles in Equine Fracture Course.

Goodrich L. a. Navicular bursoscopy; b. Tenoscopic examination of the carpal sheath; c. Arthroscopic surgery of the interphalangeal joints; d. Fetlock internal fixation and interphalangeal joints (wet lab); e. Proximal hindlimb, shoulders and elbow demos, misc. (wet lab); f. Distal sheath tenoscopy, annular ligament desmotomy and navicular bursoscopy (wet lab); g. Carpal slab fracture and carpal sheath (wet lab); CSU Continuing Education Advanced Arthroscopy Course. Instructor.

Goodrich L. Pre-clinical animal models for osteoarthritis: highlighting translational (an MD and veterinary surgeon perspective) and specifics of hip FAI animal modeling for disease. International Cartilage Repair Society Translational Research Committee Workshop. Webinar.

Goodrich L. Veterinary Orthopedic Technology and Innovation Forum (VOTIF) course and wet lab. Arthrex. Instructor.

Hess A, Bracken A, Nout-Lomas Y, Rao S. Gustafson D, Bass L. Pharmacokinetics of a long-acting intramuscular dopamine agonist in healthy horses. American Association of Equine Practitioners. Podium.

Kawcak C. a. Arthroscopic surgery of the carpus (lab); b. Arthroscopic surgery of the fetlock joints (lab); c. Arthroscopic surgery of the tarsocrural joint (lab); d. Approaches to the plantar pouch of the tarsocrural joint; e. Arthroscopic surgery of the fetlock joint. CSU Continuing Education Basic Arthroscopy Course. Instructor and Course Coordinator.

Kawcak C. a. Arthroscopic surgery of the digital flexor tendon sheath; b. Fetlock internal fixation and interphalangeal joints (wet lab); c. Proximal hindlimb, shoulders and elbow demos, misc. (wet lab); d. Distal sheath tenoscopy, annular ligament desmotomy and navicular bursoscopy (wet lab); e. Carpal slab fracture and carpal sheath (wet lab); CSU Continuing Education Advanced Arthroscopy Course. Instructor and Course Coordinator.

Kawcak C. Aftercare Panel. CSU Advanced Equine Arthroscopy Course. Moderator.

Kawcak C. Equine lameness — Diagnostic arthroscopy and gait analysis laboratories. American College of Veterinary Sports Medicine and Rehabilitation Annual Symposium. Instructor and Chair.

Kawcak C. Joint injection laboratory. American Association of Equine Practitioners Focus on Field Medicine. Instructor.

Kawcak C. Orthobiologics in canine and equine medicine. American College of Veterinary Sports Medicine and Rehabilitation Annual Symposium. Panelist.

Kawcak C. a. Surgical options for kissing spines; b. Treatment of stifle issues; c. Treatment of tendon sheath injuries. American Association of Equine Practitioners. Podum.

King M. a. Equine aquatic therapy: Review and clinical application; b. Shake, rattle, and roll: Guide to therapeutic modalities used in equine practice; c. Measurements of success: Monitoring response to rehabilitation; d. Therapeutic exercises: Can we make a difference?; e. Equine axial skeleton dysfunction and rehabilitation. New York State Veterinary Conference. Invited Speaker.

King M. Equine myofascial exam and functional assessment – 3 days. Animal Rehabilitation Institute. Instructor.

King M. a. Equine axial skeleton dysfunction and rehabilitation; b. Equine rehabilitation: Can we make a difference?; c. Equine aquatic therapy: Scientific review and clinical application; d. Measurements of success: Monitoring response to rehabilitation; e. Shake, rattle, and roll: Modalities review; f. From PT to Grand Prix. Minnesota Veterinary Medical Association. Invited Speaker.

King M. Equine rehabilitation therapeutic exercise (wet lab). Minnesota Association of Equine Practitioners. Instructor.

King M. a. Key objective measurements and outcomes for rehabilitation success: Testing and decision making; b. Man vs. machine; c. IMU/Lameness Locator/SLEIP Application (we lab). American College of Veterinary of Sports Medicine and Rehabilitation. Podium.

King M. Poor performance case presentation. Ignite. Invited Speaker.

King M. Post-operative colic rehabilitation: Can we make a difference? Rood and Riddle Symposium. Podium.

King M. a. Rehabilitation devices: Are they worth it?; b. Re-introduction to exercise; c. How can we help post-op colics return stronger? European College of Veterinary Surgeons. Invited Speaker.

King M. a. Rehabilitation techniques; b. Role of rehabilitation in cervical pain and dysfunction; c. Integrative case management. Cervical Spin Initiative. Invited Instructor.

Kloser H, Thampi P, Pezzanite L, Boxleitner T, Rodriguez N, Chow L, Dow S, Sikes K, Santangelo K, Goodrich L, Johnstone B. Injected equine articular cartilage progenitor cells are more efficacious than source-matched mesenchymal stromal cells in a mouse model of post-traumatic osteoarthritis. Orthopedic Research Society Annual Conference. Poster.

Kloser H, Thampi P, Pezzanite L, Boxleitner T, Rodriguez N, Chow L, Dow S, Sikes K, Santangelo K, Goodrich L, Johnstone B. Injected equine articular cartilage progenitor cells are more efficacious than source-matched mesenchymal stromal cells in a mouse model of post-traumatic osteoarthritis. University of Colorado 6th Annual Orthopedic Research Symposium & D'Ambrosia Diversity Lectureship. Poster.

Kloser H, Thampi P, Pezzanite L, Boxleitner T, Rodriguez N, Chow L, Dow S, Sikes K, Santangelo K, Goodrich L, Johnstone B. Equine stromal cell injections improve osteoarthritis mobility and histology outcomes in injured mice. CSU Summer Translational Talks Research Celebrations. Poster.

Kloser H, Thampi P, Boxleitner T, Rodriguez N, Johnstone B, Sikes K, Santangelo K, Goodrich L. Do equine stromal cells maintain pre-injury mobility in a mouse osteoarthritis model? CSU College of Veterinary and Biomedical Sciences Research Day. Poster.

Linde P, Chow L, Sabino I, Williams Z, Impastato R, Dow S, Pezzanite L. Effect of innate immune pathway agonists on synovial cells towards improved osteoarthritis treatment. University of Colorado 6th Annual Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship. Poster.

Luedke L. Updates in Equine Laparoscopy. CSU Annual Conference for Veterinarians and Technicians.

Luedke L. Updates in Skin Grafting. American College of Veterinary Surgeons Annual Surgery Summit. Podium.

Nelson B. Preclinical models session – Immunology in preclinical animal models. Orthopaedic Research Society Annual Meeting. Moderator.

Nelson B, Nout-Lomas Y, Seim III H, Easley J. Ex vivo analysis and preliminary clinical outcomes of a modified approach to ventral cervical stabilization in horses: An update on the polyaxial pedicle screw and rod technique. European College of Veterinary Surgeons, Annual Meeting. Podium.

Nelson B, Nout-Lomas Y, Seim III H, Easley J. Update on the polyaxial pedicle screw and rod technique for ventral cervical stabilization in horses without an interbody fusion device. American College of Veterinary Surgeons Surgery Summit. Podium.

Patel A, Piquini G, Chow L, Impastato R, Hendrickson D, Dow S, Pezzanite L. Transcriptomic responses in synovial fluid cells and circulating leukocytes in horses with progressive osteoarthritis. CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Poster.

Pezzanite L. Updates on orthobiologic therapies in equine practice. CSU Annual Conference Veterinary Continuing Education. Podium.

Pezzanite L. a. Wound cleansing and preparation; b. Role of biofilms in non-healing wounds; c. Wound debridement and evaluation; d. Wound closure and skin grafting; e. Second intention wound healing part I; f. Second intention wound healing part II. CanWest Veterinary Conference, Alberta Veterinary Medical Association. Instructor.

Plaisance C, Chow L, Engiles J, Goodrich L, Santangelo K, Dow S, Pezzanite L. Transcriptomic response of equine synovial tissues following immune conditioned cellular therapy to treat septic arthritis. CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Poster.

Rockow M, Griffenhagen G, Landolt G, Hendrickson D, Pezzanite L. Current antimicrobial use in horses undergoing exploratory celiotomy: a survey of board-certified equine specialists. CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Poster.

Sabino I, Chow L, Linde P, Williams Z, Impastato R, Dow S, Pezzanite L. Innate immune pathway activation to modulate mesenchymal stromal cell interaction with synovial cells to treat osteoarthritis. University of Colorado 6th Annual Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship. Poster.

Seabaugh K. The scientific evidence supporting the use of biota orientalis for the treatment of osteoarthritis. American Association of Equine Practitioners Annual Conference. Invited Speaker.

Singer J, Williams Z, Easley J, McGilvray K, Dow S, Impastato R, Shaw K, Awad M, Earley E, Stoneback J, Pezzanite L. Cellular immunotherapy to reduce infection and promote implant retention of bone-anchored limbs. University of Colorado 6th Annual Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship. Poster. *Visiting Trainee Poster Award Finalist.*

Stoner A, Pezzanite L, Alfonso N, Dow S, McGilvray K. Field-deployable drug delivery for open wound management. NSF I-Corps Hub West Annual Lightning Round Team Pitch Showcase. Podium.

Stoner A, Pezzanite L, Alfonso N, Dow S, McGilvray K. Field-deployable drug delivery for open wound management. CSU Demo Day. Poster.

Story M. Rehabilitation for the athlete: developing a protocol. Rood and Riddle Intern Alumni Symposium. Invited Speaker.

Story M. a. Treatments for Equine Cervical Pain and Dysfunction; b. Whole Horse Examination. Equine Spine Initiative. Invited Speaker.

Winther T, Goodrich L, Morgan K. Equine stromal cells: effects of non-ribosomal peptides on proliferation and viability. Vail Scientific Summit. Poster.

Winther T, Goodrich L, Morgan K. Equine stromal cells: effects of non-ribosomal peptides on proliferation and viability. University of Northern British Columbia Research Poster Convention. Poster.

Winther T, Goodrich L, Morgan K. Equine stromal cells: effects of non-ribosomal peptides on proliferation and viability. International Congress of National Products Research. Podium.

Taryn Boxleitner and "Dash"

Jen Daniels and "JD"

focus *two*

INVESTIGATIONS OF THE ORIGINS OF NEURO-MUSCULOSKELETAL DISEASE

a. Neuro-musculoskeletal pain and dysfunction
b. Biomechanics and sensory input
c. Repetitive stress response
d. Cell markers

PUBLICATIONS AND PRESENTATIONS

REFEREED PUBLICATIONS

Ammons D, Chow L, Goodrich L, Bass L, Larson B, Williams Z, Stoneback J, Dow S, Pezzanite L. Characterization of the single cell landscape in normal and osteoarthritic equine joints. Annals of Translational Medicine. 2024 October; 12(5):88. PMID: 39507442.

Bonilla A, Sikes K, Burton L, Chow L, Kurihara J, Santangelo K, Dow S, Easley J. Immunization against nucleus pulposus antigens to accelerate degenerative disc disease in a rabbit model. Frontiers Veterinary Science. 2024 May; 11:1382652. PMID: 38803805.

Chow L, Kawahisa-Piquini G, Bass L, Hendrickson D, Patel A, Rockow M, Dow S, Pezzanite L. Correlation of fecal microbiome dysregulation to synovial transcriptome in an equine model of obesity associated osteoarthritis. Annals of Translational Medicine. 2024 December; 12(6):112. PMID: 39817240.

Henderson C, Story M, Nout-Lomas Y. Neck pain but not neurologic disease occurs more frequently in horses with transposition of the ventral lamina from C6 to C7. Journal of the American Veterinary Medical Association. 2024 May; 262(9):1215-1221. PMID: 38810659.

(left to right) Jen Daniels, Natalie Lombard, Savanna Parrent

Kim L, Kreitner K, Scott D, Seabaugh K, Duncan C, Magzamen S. The effects of ambient air pollution exposure on Thoroughbred racehorse performance. Equine Veterinary Journal. 2025 May; 57(3):712-722. Epub 2024 September. PMID: 39228107.

Migliorisi A, Nottle B, Smanik L, Nout-Lomas Y, Hassel D. Making a complete blood count more complete: Neutrophil-to-lymphocyte ratio in horses with colic syndrome. Equine Veterinary Education. 2024 July; 36(S13):53–53.

Minton D, Ailiani A, Focht M, Kersh M, Marolf A, Santangelo K, Salmon A, Konopka A. The common marmoset as a translational model of age-related osteoarthritis. GeroScience. 2024 June; 46(3):2827-2847. Epub March. PMID: 38466454.

Mlawer S, Pinto F, Sikes K, Connizzo B. Coordination of glucose and glutamine metabolism in tendon is lost in aging. bioRxiv [Preprint]. 2024 December; 12.19.629426. PMID: 39763790.

Sikes K, Andrie K, Wist S, Verma N, Yanke A, Santangelo K, Frisbie D, Cole B. Acute tear versus chronic-degenerated rotator cuff pathologies are associated with divergent tendon metabolite profiles. Connective Tissue Research. 2024 November; 14:1-14. PMID: 39540635.

Walsh M, Latham A, Zhang Q, Jacobs R, Musci R, LaRocca T, Moreno J, Santangelo K, Hamilton K. Non-transgenic guinea pig strains exhibit divergent age-related changes in hippocampal mitochondrial respiration. Acta Physiologica (Oxford). 2024 August; 240(8):e14185. Epub June. PMID: 38860650.

RESEARCH ABSTRACTS, PRESENTATIONS, PROCEEDINGS

Allen K, Johnson S, Kawcak C. From the Barn to the Ring: Managing Early Degenerative Joint Disease. American Regent. Sunrise Session Recording.

Aragon J, Brekhus C, Gadomski B, Sikes K, Koch D. Determination of the size and biomechanical properties of the sheep and rabbit common calcaneal tendon as preclinical models for the human Achilles tendon. National Veterinary Summer Scholars Symposium. Poster.

Cooper F, Werpy N, Nelson B, Biedrzycki A. Statistical shape models of equine navicular bones show large intra-breed morphological variation. American College of Veterinary Surgeons Surgery Summit. Podium.

Goodrich L. a. Are there differences between human and animal joint biology?; b. Assessing equine outcomes and a potential International Cartilage Repair Society Registry pathway. International Cartilage Repair Society Focus Meeting on Knee Osteotomies. Podium.

Goodrich L. Histologic and biomechanical characteristics of osteochondral allografts. Vail Scientific Summit. Invited Speaker.

Kawcak C. The Spine as a Source of Poor Performance. American College of Veterinary Surgeons Surgery Summit. Podium.

Kawcak C. Catastrophic Injury Prevention in Thoroughbred Racehorses. VetPD. Panelist.

Kawcak C. Pathophysiology of and New Insights into Subchondral Bone Disease. American College of Veterinary Sports Medicine and Rehabilitation Annual Symposium.

Pezzanite L. Research updates on lameness prevention. CSU Equine Sciences Showcase, Temple Grandin Equine Center. Podium.

Potter A, Van Zeeland E, Burton L, Easley J, Nordgren T, Sikes K. Characterizing the mobility and activity response in a mouse acl injury model. CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Poster.

Potter A, Van Zeeland E, Burton L, Easley J, Nordgren T, Sikes K. The role of fatty acid metabolism in inflammatory modulation following ACL rupture: Insights into PTOA progression from a translational model. University of Colorado Anschutz Medical Campus Orthopaedic Research Symposium. Poster. *Visiting Mentee Poster Award Finalist.*

Sanchez V, Scott D, Quintana J, Viola L, Seabaugh K, Contino E, Magzamen S, Duncan C. Air quality at US equine Eventing competitions. Proceedings 25th Annual CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Podium.

Scott D, Contino E, Seabaugh K, Magzamen S, Duncan C. Animals and air pollution: Lessons from equine athletes. Proceedings 17th International Symposium on Veterinary Epidemiology and Economics. Podium.

Story M. The Microbiome and Chronic Inflammation. American College of Veterinary Sports Medicine and Rehabilitation. Invited Speaker.

Williams Z, Chow L, Piquini G, Patel A, Rockow M, Dow S, Pezzanite L. Gut microbiome dysbiosis in an equine model of spontaneous osteoarthritis. Front Range Microbiome Symposium. Poster.

Williams Z, Chow L, Plquini G, Patel A, Rockow M, Dow S, Pezzanite L. Gut microbiome dysregulation is associated with sustained inflammation and differential gene expression in equine progressive osteoarthritis. CSU College of Veterinary Medicine and Biomedical Sciences Research Day. Podium.

Williams Z, Chow L, Sabino I, Impastato R, Goodrich L, Dow S, Pezzanite L. Longitudinal changes in fecal microbiome and circulating leukocyte gene expression in an equine model of post-traumatic osteoarthritis. University of Colorado 6th Annual Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship. Poster.

Williams Z, Chow L, Sabino I, Impastato R, Piquini G, Bass L, Hendrickson D, Dow S, Pezzanite L. Correlation of fecal microbiome dysregulation to synovial transcriptome in a spontaneous equine model of osteoarthritis. University of Colorado 6th Annual Orthopedic Research Symposium and D'Ambrosia Diversity Lectureship. Poster. *Visiting Trainee Poster Award Finalist.*

Winston S, Pezzanite L, Dow S, McGilvray K, Puttlitz C. Parametric finite element analysis for the development of a gradient scaffold. Computer Methods in Biomechanics and Biomedical Engineering International Symposium. Podium.

focus *three*

IMPROVE THE DETECTION OF NEURO-MUSCULOSKELETAL DISEASE

a. Advanced analytics
b. Imaging modalities
c. Intrepretation of clinical examination
d. Novel diagnostic techniques
e. Behavior

PUBLICATIONS AND PRESENTATIONS

TEXTBOOK CHAPTERS

Nelson B, Goodrich L. Elbow and shoulder. Hinchcliff, Kaneps, and Goer, Equine Sports Medicine and Surgery, 3rd edition. Saunders Elsevier. 23: 456-477.

REFEREED PUBLICATIONS

Damone J, Bass L, Gadomski B, Rao S, Frank C, Moorman V. Biomechanical and histological variables differ by site but not by lameness in equine digital cushion samples from forelimbs. Journal of Equine Veterinary Science. 2024 November; 142:105178. Epub August. PMID: 39182697.

Esselman A, Johnson S, Frisbie D, Barrett M, Zhou T, Contino E. Substantial variability exists in the interpretation of survey radiographs among equine veterinarians. Equine Veterinary Journal. 2025 January; 57(1):169-182. PMID: 38194693.

Liu S, Herbst M, Schaefer J, Weber T, Vogt S, Ritschl L, Kappler S, Kawcak C, Stewart H, Siewerdsen J, Zbijewski W. Feasibility of bone marrow edema detection using dual-energy cone-beam computed tomography. Medical Physics. 2024 March; 51(3):1653-1673. Epub February. PMID: 38323878.

Nelson B, Mäkelä J, Lawson T, Patwa A, Snyder B, McIlwraith CW, Grinstaff M, Seabaugh K, Barrett M, Goodrich L, Kawcak C. Longitudinal in vivo cationic contrast-enhanced computed tomography classifies equine articular cartilage injury and repair. Journal of Orthopedic Research. 2024 October; 42(10):2264-2276. Epub May. PMID: 38715519.

Ortved K, Alward L, Cowles B, Linardi R, Barot D, Usimaki A, Fedie JR, Amodie D, Goodrich L. Use of quantitative mass spectrometry-based proteomics and ELISA to compare the alpha 2 macroglobulin concentration in equine blood-based products processed by three different orthobiologic devices. Frontiers Veterinary Science. 2024 February; 11:1335972. PMID: 38406632.

Panizzi L, Vignes M, Dittmer K, Waterland M, Rogers C, Sano H, McIlwraith CW, Riley C. Infrared spectroscopy of synovial fluid shows accuracy as an early biomarker in an equine model of traumatic osteoarthritis. Animals (Basel). 2024 March; 14(7):986. PMID: 38612225.

Peat F, Kawcak C, McIlwraith CW, Berk J, Keenan D. Concurrent radiological and ultrasonographical findings in the forelimb proximal sesamoid bones and adjacent suspensory ligament branches in yearling and 2-year-old Thoroughbred sales horses. Equine Veterinary Journal. 2025 May; 57(3):654-665. Epub 2024 July. PMID: 39039612.

Peat F, Kawcak C, McIlwraith CW, Berk J, Keenan D, Selberg K, Ojeda A. Ultrasonography of the suspensory ligament branches in yearling and 2-year-old Thoroughbred sales horses: Prevalence, progression of findings and associations with racing performance. Equine Veterinary Journal. 2025 March; 57(2): 384-397. Epub 2024 July. PMID: 39007207.

Peat F, Kawcak C, McIlwraith CW, Keenan D, Berk J, Mork D. Radiological findings in the proximal sesamoid bones of yearling and 2-year-old Thoroughbred sales horses: Prevalence, progression and associations with racing performance. Equine Veterinary Journal. 2025 January; 57(1):87-100. Epub 2024 January. PMID: 38237926.

Smanik L, Selberg K, Kawcak C, Stewart H, Goodrich L. Computed tomography and fluoroscopy versus radiographic guidance for internal fixation of simulated dorsomedial-plantarolateral central tarsal bone fractures in nonracehorses. Veterinary Surgery. 2024 January; 53(1):155-166. Epub 2023 September. PMID: 37770751.

van Veggel E, Vanderperren K, Selberg K, Bergman H, Hoogelander B. The evolution of lesions on follow-up magnetic resonance imaging of the proximal metacarpal region in non-racing sport horses that returned to work (2015-2023). Animals (Basel). 2024 June; 14(12):1731. PMID: 38929351.

Dr. Mindy Story greeting a patient (Dane Aragon/TMI Photo)

RESEARCH ABSTRACTS, PRESENTATIONS, PROCEEDINGS

Barton C, Nelson B, Winther T, Maker C, Goodrich L. Tenoscopic-guided resection of the manica flexoria utilizing radiofrequency energy. American College of Veterinary Surgeons Surgery Summit, Residents Forum. Poster. *Dr. Charlie Barton received second place in the Resident Forum for Clinical Research Presentation.*

Barton C, Nelson B, Winther T, Maker T, Goodrich L. Tenoscopic-guided resection of the manica flexoria utilitzing radiofrequency energy. Vail Scientific Summit. Poster. *Dr. Charlie Barton received first place in the PostDoctoral Poster Competition.*

Bonilla A, Nelson B, Easley J. Detection of Modic changes in an ovine model of intervertebral disc degeneration. Orthopedic Research Society, Annual Meeting. Podium.

Bukovec K, Kiger K, Bass L, Ayers J, McNulty E, Denkers N, Kendall L, Mathiason C. Deer oh deer, what happened to your leg! American Association for Laboratory Animal Sciences National Meeting. Podium.

Contino E. What they never told me about being a performance horse veterinarian. American Association of Equine Practitioner Round Table Discussion. Virtual.

Contino E. Poor performance in the Sport Horse. American College of Veterinary Surgeons Surgery Summit. Podium.

Contino E. a. Diagnosis of suspensory disease: from blocking to imaging; b. Diagnosing neck, back and SI dysfunction: from examination to imaging; c. Poor performance in equine athletes; d. Diagnostic analgesia: the distal limb; e. Diagnostic analgesia: beyond the foot; f. Implications of sales radiographs; g. Subjective versus objective lameness evaluation; h. Variability in interpretation of pre-purchase radiographs. 39th World Veterinary Association Congress. Podium.

Contino E. a. Go wild- Supplementing the routine lameness examination; b. Ultrasound wetlab. American Association of Equine Practitioner's Focus on Field Medicine. Instructor.

Contino E. Lameness in horses- Diagnostic analgesia. VETgirl. Webinar.

Contino E. a. Diagnosing and managing axial skeletal pain; b. Exploring cases of poor performance. Colorado Veterinary Medical Association Annual Convention. Podium.

Kawcak C. Wearable technology: A game changer. American Association of Equine Practitioners Annual Conference. Podium.

Kawcak C. Fetlock lameness across Ddsciplines. American College of Veterinary Sports Medicine and Rehabilitation Annual Symposium. Podium.

Kawcak C. Advancements in diagnostic imaging and the impact on the safety and welfare of the racehorse. Thoroughbred Club of America. Panel Moderator.

Kawcak C. What can 'wearable' technology do to identify poor performance? American College of Veterinary Surgeons Surgery Summit. Podium.

Kawcak C. Progression of radiographic and ultrasound findings in 1–2-year-old sales Thoroughbreds. Rood and Riddle Intern Alumni Symposium. Podium.

Kawcak C. Wearable technology in horses. Kester News Hour. American Association of Equine Practitioners Annual Meeting. Guest.

Kawcak C. What are the most critical bits of evidence required to advance the field on behalf of racing? What studies are required to obtain the evidence? Global Summit: Equine Safety and Technology. Podium.

Kawcak C, Johnson S. Confessions of a seasoned vet: Mistakes made and lessons learned. American Association of Equine Practitioners Annual Meeting. Podium.

Nelson B. Advanced Imaging of Bone, Cartilage, and Joint. Orthopaedic Research Society Annual Meeting. Moderator.

Nout-Lomas Y. Electrodiagnostics for horses with gait abnormalities. American College of Veterinary Internal Medicine. Podium.

Nout-Lomas Y. Neck pain but not neurologic disease occurs more frequently in horses with transposition of the ventral lamina from C6 to C7. Veterinary Vertex, American Veterinary Medicine Association Podcast.

Peat F, Kawcak C, McIlwraith CW, Berk J, Keenan D. Concurrent findings in the proximal sesamoid bones and adjacent suspensory ligament branches in yearling and two-year-old Thoroughbred sales horses. American Association of Equine Practitioners Proceedings, p. 489-490.

Peat F, Kawcak C, McIlwraith CW, Berk J, Keenan D, Selberg K, Ojeda A. Ultrasonography of the suspensory ligament branches in yearling and two-year-old Thoroughbred sales horses. American Association of Equine Practitioners. Proceedings, p. 487-488.

Stewart H, Sidky E, Pan X, McIlwraith CW, Duff M, Kawcak C. Sparse-view imaging with equine cone-beam computed tomography. Orthopaedic Research Society. Proceedings, p. 1925.

Story M. The Equine Athlete: Building Optimal Health and Performance for the Sport Horse. Pain and pain patterns - using the myofascial examination to ask the right questions. Platinum Performance Veterinary Continuing Education Event. Invited Speaker.

Story M. Equine myofascial examination laboratory. American Association of Equine Practitioners Focus on Field Medicine. Invited Speaker.

Sensor plate motion capture in the ORC Gait Analysis Laboratory

ADVANCED ANALYTICS

Dr. Lauren Smanik (Dane Aragon/TMI Photo)

Objective equine gait analysis has a long history with the first recorded publications on the topic dating back 250 years. These early studies examined the anatomic structure of horses to assist artists in creating more accurate depictions. Despite these early studies, and challenges caused by limitations of the human eye, there remained a long-standing debate in what was an accurate image of a horse while galloping. It was not until the invention of photography that a faster equine gait was captured on film, confirming a suspension period in a horse trot. This ushered in what researchers call the "Golden Age of Equine Gait Analysis."

With rapid technological and computing advancements of the 1900s, and as horses gained popularity as athletes and companion animals, equine biomechanical research expanded significantly. Research focused on advanced gait analytics in the ORC has been growing for the last 20 years, driven by the need for objective lameness evaluations, and industry partners hoping to develop new technologies.

Pioneering work by Dr. Melissa King combined force plate, optical motion capture, and electromyography to investigate the effects of underwater treadmill exercise in mitigating experimentally induced carpal osteoarthritis. This initiative marked a turning point in establishing objective, data-driven foundations for equine rehabilitations. Further foundational work by Dr. Valerie Moorman, under the mentorship of Drs. C. Wayne McIlwraith, Chris Kawcak, Raoul Reiser, and Mick Peterson, focused on validating 3D optical capture and inertial measurement unit (IMU) systems with healthy horses for clinical use in lameness exams. Dr. Moorman identified movement changes that occurred with lameness at a walk and trot using limb-based sensors. Notable early contributions that changed the course of gait analysis in the ORC include Dr. Josh Donnell, who compared force plate analysis data with Lameness Locator® outputs, establishing objective baselines lameness evaluation tools.

Building on this early work, objective gait outcome parameters have since become standard practice in a growing number of industry-sponsored research projects conducted at CSU. These formative efforts catalyzed the expansion of the ORC gait laboratory to include comprehensive 3D analysis capabilities for biomechanical modeling. The resulting data, produced through collaborations, remain foundational for understanding joint stress and injury mechanisms in Thoroughbred racehorses.

The ORC's advanced analytics research is unique because of our deeply interdisciplinary and collaborative work with not only other CSU departments and colleges, but universities and industry partners across the country and internationally. This ever-expanding team is at the forefront of assessing novel methods for monitoring conditioning, training, and injury prevention. Numerous studies are currently underway, including validation of markerless motion capture in lameness models, IMU and machine learning comparisons to gold-standard technologies, and quantifying training loads and gait asymmetries with performance outcomes.

In response to a growing demand from both the scientific community and equine industry for research that identifies reliable methods to evaluate sport-specific performance and injury risk in horses, Drs. Melissa King and Sandro Colla have successfully secured competitive funding from the CSU College Research Council and the American Quarter Horse Foundation. Their projects focus on validating the use of IMU sensors to quantify biomechanical loading in a reversible lameness model, advancing the role of wearable technology in equine gait analysis. In 2025, their research will expand further with support from the Grayson Jockey Club Research Foundation to investigate the reliability of smartphone-based biomechanical sensors during clinical lameness exams. Additionally in 2025, the ORC will start the search for a new Professor/Team Scientist in Machine Learning, Biostatistics, and Bioinformatics. This new faculty member will hold the Abigail Kawananakoa University Endowed Chair and will focus on advancing our interdisciplinary research on computational methods with experimental biology for integration into clinical examinations and laboratory techniques.

Drs. Sandro Colla and Melissa King (Dane Aragon/TMI Photo)

As we progress in our research, advanced analytics technology in the ORC will be used to better assess equine well-being for both clinical and research cases. For our preclinical models, more wholistic outcomes are needed to improve assessment of management strategies. Today we are limited in the reliability of our clinical outcomes, and more wholistic strategies are needed to optimize patient well-being. Movement, physiologic response to work and behavior are 3 of the outcomes that are being evaluated collectively in the laboratory.

These advancements have been made possible through the ORC's strong network of industry and academic collaborations. Drs. King and Colla have forged a valuable partnership with Vayu Technologies, whose cutting-edge biomechanical sensor systems and data analytics expertise have substantially enhanced the precision and scalability of equine gait analysis. Their ongoing collaboration facilitates real-time data acquisition and high-resolution movement analytics, contributing meaningfully to the clinical utility of wearable technology.

Dr. Chris Kawcak is leading one of the Association of American Equine Practitioners Biometric Studies in partnership with Equimetrics. The partnership, spearheaded by Dr. McIlwraith's longtime collaboration with the team, also includes Dr. Steve Simske's signal processing team in Systems Engineering at CSU, and Sarah Shaffer's engineering team at the Southwest Research Institute in San Antonio, TX. There are 120 two-year-old Thoroughbred racehorses wearing sensors during breezes and races to capture data indicative of impending injury.

Advanced equine gait analysis is an extensive field that requires a dedicated, multidisciplinary team of experts consisting of veterinarians, researchers, and staff. The ORC remains a global leader in this field, and this report highlights some of our team's ongoing contributions toward improving equine health, performance, and injury prevention through innovation in biomechanics and data science.

Dr. Chris Kawak (Dane Aragon/TMI Photo)

ADVANCED ANALYTICS

FROM IMPACTFUL STUDIES FOCUSED ON ADVANCED ANALYTICS AND OBJECTIVE GAIT ANALYSIS

Interleukin-1β as an articular process joint intra-articular model induces synovitis and signs of acute neck pain in horses

M. Story, M. King, Y. Nout-Lomas, M. Barrett, C. Kawcak, D. Frisbie, C.W. McIlwraith, K. Haussler

Sponsored by: College Research Council, Colorado State University and The Colorado Racing Commission

The objective of this study was to develop and define a model of acute neck pain in an equine cervical articular process joint (APJ) using recombinant equine IL-1β (reIL-1β). Twelve horses participated in this experimental study receiving a randomly assigned, unilateral intra-articular injection of 50 ng (n = 6) or 100 ng (n = 6) of reIL-1 and saline (contralateral side as control) into the C5-to-C6 APJ. Blinded ultrasonographic, clinical, and biomechanical parameters were evaluated between 4 hours and 14 days. The findings of this study revealed that there was a significant increase in APJ effusion on ultrasonographic examination that peaked at 24 hours (P = .0256; effect size, 0.8312; CI, 1.0594 to 0.629). There was a time effect on the clinical examination score (myofascial pain and stiffness) and a significant decrease in stride length and velocity at 24 hours. There was an adverse event (extravasation of injectate) in 1 horse. Ultrasonographic evidence of the presence and severity of APJ effusion was readily identified and tracked over time. Unilateral injection of the APJ with reIL-1β induced clinical signs of myofascial pain, neck stiffness, and gait adaptations. Using individual control horses, rather than a contralateral saline injection within the same horse, would improve our understanding of the clinical presentation of acute APJ pain using this model. Diagnosing the presence, localization, and clinical effects of neck pain in horses remains challenging and would benefit from the establishment of an experimental model. The induction of acute synovitis using reIL-1β within the C5-to-C6 APJ opens the door for future studies to ultimately better understand equine cervical pain and dysfunction.

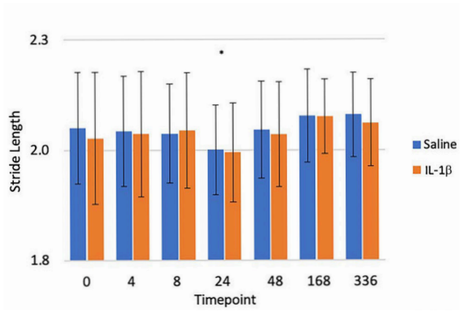


Figure 1 (above): There is a main effect of time (P=.0057), with a significant decrease in stride length at 24 hours. There was not a significant treatment effect between saline and reIL-1β. *Indicates significance.

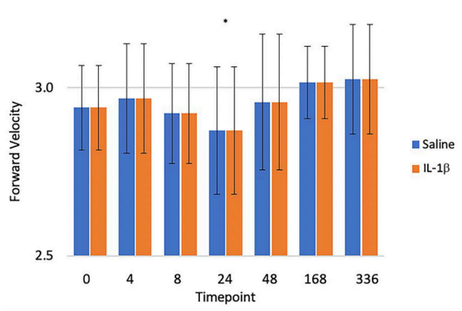


Figure 2 (above): In the group of horses categorized as responders, there was a main effect of time on forward velocity, with a significant (P < .0001) decrease at 24 hours independent of the injectate. *Indicates significance.

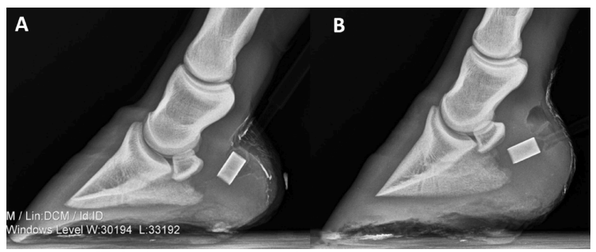
Biomechanical and histological variables differ by site but not by lameness in equine digital cushion samples from forelimbs

J. Damone, L. Bass, B. Gadomski, S. Rao, C. Frank, V. Moorman

The equine digital cushion (DC) has been a poorly understood structure regarding its mechanical properties and composition. The objective of this study was to develop a sampling technique and to compare the biomechanical and histologic properties of DC between lame and non-lame forelimbs. Both forefeet from horses with induced carpal lameness were radiographed prior to humane euthanasia. Radiographs were used to guide sample collection of two, post-mortem, midline DC samples, palmar and dorsal, via an 8mm biopsy punch. Samples were subjected to compressive testing to determine elastic modulus. Histological evaluation was used to quantify collagen, adipose, ground substance, elastic fibers, and blood vessels. Comparisons of variables between palmar and dorsal DC sites and lame and non-lame limbs were made using student's t-tests or Wilcoxon signed rank tests with P < 0.05. There were no differences in histologic or biomechanical properties in DCs of lame and non-lame forelimbs. The dorsal DC sampling site had a significantly higher median elastic modulus (median: 0.054 MPa, range: 0.001 – 2.110 MPa) and a larger median percentage of ground substance (median: 15 %, 95 % CI: 3 – 30 %) compared to the palmar DC site (elastic modulus: median: 0.023 MPa, range: 0 – 0.576 MPa; ground sub-stance: median 5 %, 95 % CI: 3 – 25 %) (P = 0.03, <0.001; respectively). This study demonstrated that adequate samples could be collected from the DC for biomechanical and histological analysis. Differences in elastic modulus and ground substance between palmar and dorsal samples may reflect different roles of these sites within the DC.

Figure 1 (left): Lateral-medial radiograph of a forefoot demonstrating the location of each digital cushion sampling site; A) represents the location of the palmar site and B) represents the location of the dorsal site.

Figure 2 (below): Lateral-medial radiograph demonstrating the positioning of the 8 mm biopsy punch used to obtain the digital cushion samples just prior to the piece of digital cushion being removed. A) The biopsy punch is located at the palmar digital cushion sample site. B) The biopsy punch is located at the dorsal digital cushion sample site.



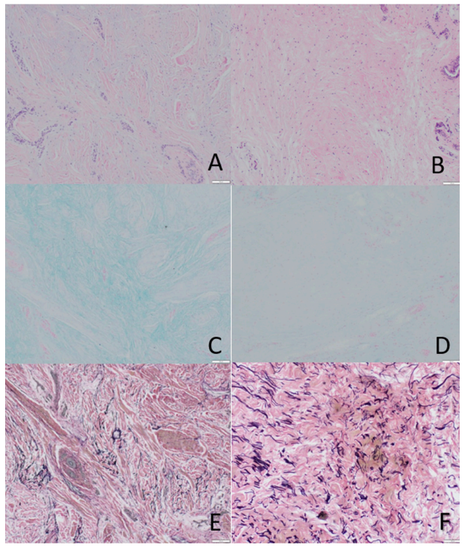


Figure 3 (above): Photograph of a representative histologic images comparing dorsal and palmar samples. Dorsal digital cushion samples stained with hematoxylin and eosin (A), Alician Blue (C), and Verhoeff's van Giessen (E) stains. Palmar digital cushion samples stained with hematoxylin and eosin (B), Alician Blue (D), and Verhoeff's van Giessen (F) stains. The difference in ground substance is particularly clear with Alician Blue stain with significantly more ground substance in the dorsal sample (C).

Blood flow restriction training does not negatively alter the mechanical strength or histomorphology of uninjured equine superficial digital flexor tendons

S. Johnson, K. Sikes, J. Johnson, E. Van Zeeland, S. Wist, K. Santangelo, M. King, D. Frisbie

Sponsored by: Translational Acceleration Program (TAP) of the Translational Medicine Institute

Low load exercise training with blood flow restriction (BFR) has become increasingly used by human physical therapists to prescribe controlled exercise following orthopedic injury; its effects on the equine superficial digital flexor tendon (SDFT), however, are unknown. The objective of this study was to investigate outcomes of pressure specific BFR walking exercise on uninjured equine SDFT biomechanics and histomorphology. In this controlled, in vivo experiment, four forelimbs of four horses were exposed to 40 BFR-walk sessions (10-minute interval walking) on a treadmill over a 56-day study period with their contra-lateral forelimbs serving as untreated controls. Similarly, four forelimbs of four control horses were exposed to 40 sham cuff walk sessions. Forelimb SDFTs underwent non-destructive biomechanical testing and corresponding histomorphological analysis. Significance in biomechanical parameters between treatment groups was analyzed using a mixed-effects ANOVA with Tukey's post-hoc tests.

This study results showed statistically significant differences in SDFT stiffness for both first ($p = 0.02$) and last cycles ($p = 0.03$) were appreciated within the BFR treated group only, with BFR exposed forelimbs being significantly stiffer than the contralateral unexposed forelimbs. When normalized to cross-sectional area, no significant differences were appreciated among treatment groups in elastic modulus for the first ($p = 0.5$) or last cycles ($p = 0.4$). No histological differences were appreciated among treatment groups according to Bonar, Movin, or musculotendinous junction evaluation criteria. Short-term comparisons were performed in a small sample population without correlation to performance outcome measures. Optimal occlusion per-centages and walk protocols remain unknown.

This study demonstrated no negative impact of BFR on mechanical strength of the equine SDFT; however, evidence suggests that BFR results in increased tendon stiffness based on biomechanical testing and subsequent calculations. No consistent detrimental histomorphological changes were seen.

Figure 1 (above): Application of a limb protection sleeve (white arrow) secured with elastic adhesive tape and inflated BFR cuff to the left forelimb of a horse in preparation for walk exercise. The personalised tourniquet system (PTS) adjusts pressure dynamically to maintain individual levels of occlusion based on daily measured limb occlusion pressures (LOP).

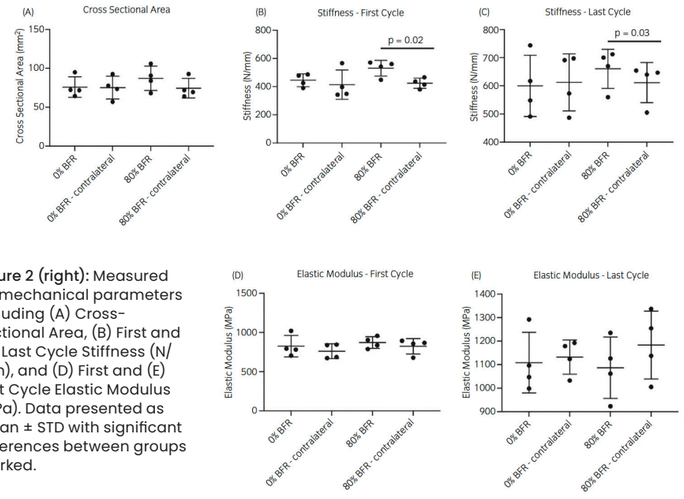


Figure 2 (right): Measured biomechanical parameters including (A) Cross-Sectional Area, (B) First and (C) Last Cycle Stiffness (N/mm), and (D) First and (E) Last Cycle Elastic Modulus (MPa). Data presented as mean ± STD with significant differences between groups marked.

FOR THE COMPLETE STUDY, VISIT: HTTPS://COL.ST/NAT9S

REVENUE & EXPENSES

REVENUE	FY2024
Total Interest	$815,489
Medical Center Clinical Service Total	$1,442,309
Research Project Accounts Total	$7,842,930
Stallion Auction	$24,923
State Funds Total	$149,377
Total Donations	$699,524
TOTAL REVENUE	$10,974,552
EXPENSE	
Total Salaries	$1,558,391
Faculty Travel	$22,189
Materials and Supplies	$562,984
General Services	$1,417,136
Building	$1,879
Equipment	$135,805
Deficit Payments	$116,724
EXPENSE SUBTOTAL	$3,815,108
FACILITY AND ADMINISTRATIVE OVERHEAD COSTS	$619,702
TOTAL EXPENSE AND OVERHEAD	$4,434,810
ACCOUNT BALANCE	$6,539,742

REVENUE BREAKDOWN	FY2024
INTEREST ON ENDOWMENTS	
Atkinson Chair	$62,467
Cox Anthony Chair	$178,545
Iron Rose Ranch Chair	$139,258
Kawananakoa Chair	$123,472
Malone Chair	$295,978
McIlwraith Scholarship	$8,670
ORC Excellence Fund	$7,099
TOTAL INTEREST	$815,489

REVENUE BREAKDOWN	FY2024
STATE FUNDS	
Kawcak CRC Grant	$24,983
King CRC Grant	$24,890
Nelson CRC Grant	$25,000
Pezzanite CRC Grant	$24,920
Seabaugh CRC Grant	$24,584
Story CRC Grant	$25,000
STATE FUNDS TOTAL	$149,377

EXPENSE	FY2024
SALARIES	
Faculty Salaries	$736,953
Research Associate Salaries	$43,562
Administrative Salaries	$289,086
Residents	$206,942
Graduate Student Salaries	$7,065
Hourly Students	$274,784
TOTAL SALARIES	$1,558,391

GRANTS

INVESTIGATORS	SPONSOR	PROJECT TITLE	PERIOD	AMOUNT
Erin Contino, Laurie Goodrich (Co-PIs)	Zoetis	Prospective clinical trial: Evaluation of autologous protein solution (APS) as an anti-inflammatory therapeutic for adult horses with naturally-occurring lameness isolated to the medial femorotibial joint	1/1/22-12/1/25	$315,844
Erin Contino (PI), Renata Impastato, Steve Dow, Katie Seabaugh, Melissa King, Lyndah Chow, Lynn Pezzanite (Co-PIs)	Contura Vet	Evaluating the symptom-modifying and disease-modifying effects of an intra-articular polyacrylamide hydrogel in the equine osteochondral fragment model for osteoarthritis	5/1/24-4/30/25	$685,177
Erin Contino (PI), Melissa King, Mikala Vig (Co-PIs)	American Association of Rehabilitation Veterinarians	The effects of mesotherapy on back pain and range of motion in horses	5/1/24-4/30/25	$2,500
David Frisbie (PI), Myra Barrett, Katie Seabaugh, Brad Nelson (Co-PIs)	The Stone Research Foundation	Stone Foundation paste graft assessment	6/15/23-6/15/25	$395,055
David Frisbie (PI), Melissa King, Brad Nelson (Co-PIs)	Zoetis	Pilot efficacy of an equine anti-NFG mAb in the IL-IB equine synovitis model	1/1/24-12/31/24	$224,036
Laurie Goodrich (PI), Brad Nelson, Kelly Santangelo, Ben Gadomski (Co-PIs)	Advanced Research Projects Agency for Health (ARPA-H)	Novel Innovations for Tissue Regeneration in Osteoarthritis (NITRO): A minimally invasive multimodal biomaterial approach to tissue regeneration in osteoarthritis	3/26/24-4/2/26	$2,200,739
Laurie Goodrich (PI)	COEDIT/STRATA	A novel gene therapeutics approach to osteoarthritis in companion animals	2/23/24-2/28/26	$60,000
Laurie Goodrich (PI), David Frisbie, Myra Barrett, Christopher Kawcak, C. Wayne McIlwraith, Constance Chu (Co-PIs)	US Department of Defense	Development of diagnostic and treatment strategies for post traumatic osteoarthritis (PTOA)	9/1/18-6/30/24	$711,101
Laurie Goodrich (PI)	eQcell	Experimental protocol for co-culture	7/1/23-6/30/24	$108,745
Laurie Goodrich (PI), David Frisbie, Myra Barrett, Christopher Kawcak, C. Wayne McIlwraith (Co-PIs)/Constance Chu (PI)	Stanford University (US Department of Defense)	Localized gene therapy for prolonged anti-inflammatory treatment to prevent or delay PTOA in an equine model	1/15/20-1/14/25	$1,148,328
Laurie Goodrich (PI), Kirk McGilvray, Ben Gadomski, Myra Barrett, Katie Seabaugh, Brad Nelson (Co-PIs)	Nanochon	Testing and scale-up of 3D printed cartilage repair device for clinical use	5/2/22-8/31/24	$674,981
Laurie Goodrich (PI), Brad Nelson, Parvathy Thampi (Co-PIs)	Ocean Tunicell	Product development & testing of scaffolds as a repair device for clinical use	5/15/22-12/31/24	$99,952
Laurie Goodrich (PI), Brad Nelson, Charlotte Barton (Co-PIs)	American College of Veterinary Surgeons	Tenoscopic-guided resection of the manica flexoria utilizing radiofrequency energy	12/1/22-11/30/24	$12,978
Laurie Goodrich (PI), Katie Seabaugh, Brad Nelson (Co-PIs)	eQcell, Inc.	eQcell clinical trial- Use of allogeneic umbilical cord blood-derived mesenchymal cells for treatment of synovitis in horses: an efficacy study	2/1/23-6/1/24	$103,045
Laurie Goodrich (PI), Katie Seabaugh (Co-PI)	Mechano Therapeutics	STTR Phase I: Mechanically controlled drug delivery platform for joint environments	6/15/23-5/31/24	$119,924
Laurie Goodrich (PI), Brad Nelson (Co-PI)	Cayman Biomedical	KMN159 bone stimulation to enhance fracture repair: a pilot study	9/1/22-8/31/24	$113,283
Christopher Kawcak (PI), Brad Nelson, Holly Stewart, Kelly Zersen, Kurt Selberg (Co-PIs)	The Foundation for The Horse	Validation of an innovative contrast subtraction technique to detect equine bone marrow lesions using CT	10/1/20-8/30/24	$19,981
Christopher Kawcak (PI), Kurt Selberg, Holly Stewart, Lauren Smanik (Co-PIs)	The Foundation of the Horse	Development of an experimental model of palmar osteochondral disease in the horse: a pilot study	10/17/22-1/31/24	$12,403
Christopher Kawcak (PI)	Cell Drop Biosciences	Novel hydrogel-encapsulated allogeneic mesenchymal stem cell treatment of suspensory ligament and superficial digital flexor tendon injuries in the performance horse	5/15/24-5/15/25	$23,488
Christopher Kawcak (PI), Brad Nelson, Lauren Smanik (Co-PIs)	Hong Kong Jockey Club Research Foundation	Development of a CT-based biomarker of the fetlock joint disease	11/1/23-10/31/26	$314,914
Christopher Kawcak (PI), Katie Sikes, Lindsey Burton, Kelly Santangelo, Laurie Goodrich (Co-PIs)	College Research Council	Cellular persistence after intra-articular injection using encapsulated pGMB hydrogels	7/1/23-6/30/24	$24,983
Melissa King (PI), Sandro Colla, Katie Seabaugh (Co-PIs)	College Research Council	Validation of novel wearable sensor technology	7/1/23-6/30/24	$24,890
Lauren Luedke (PI), Norm Ducharme, Fabrice Rossignol, Ben Gadomski, Jimmy Johnson (Co-PIs)	College Research Council	Biomechanical properties of 3 implant techniques for prosthetic laryngoplasty in the arytenoid cartilage of ex vivo equine larynges	7/1/23-6/30/24	$22,387
Brad Nelson (PI), Laurie Goodrich, Christopher Kawcak, Ben Gadomski, Kurt Selberg, Katie Sikes, Jimmy Johnson (Co-PIs)	Grayson-Jockey Club Research Foundation	Efficacy of Tenex percutaneous ultrasonic needle tenotomy (PUNT) in the healing response of a chronic model of equine superficial digital flexor tendinopathy	4/1/24-3/31/26	$220,528
Brad Nelson (PI)	Prohibix	Joint safety study of a HYALUTE microparticles: A prolonged action hyaluronic acid	8/25/23-12/31/24	$23,001
Brad Nelson (PI), Melinda Story, Yvette Nout-Lomas, Christopher Kawcak, Jeremiah Easley (Co-PIs)	College Research Council	In vivo efficacy of an innovative minimally invasive foraminotomy approach for treatment of cervical spinal nerve root compression in horses	7/1/24-6/30/25	$25,000
Yvette Nout-Lomas (PI), Lisa Bartner, Tawfik Aboellail, Lawrence Whalen (Co-PIs)	College Research Council	Electrodiagnostic testing in horses with distal cervical vertebral compressive myelopathy	7/1/23-6/30/24	$24,335
Lynn Pezzanite (PI), Steven Dow, Dean Hendrickson, Laurie Goodrich (Co-PIs)	Grayson-Jockey Club Research Foundation	Transcriptomic response to Osteoarthritis using single cell sequencing approaches	4/1/23-3/31/25	$165,475
Lynn Pezzanite (PI), Lyndah Chow, Steven Dow (Co-PIs)	College Research Council	Identifying optimal senolytic drug therapies to treat equine osteoarthritis	7/1/23-6/30/24	$24,920
Katie Seabaugh (PI), Keana McKosh (Co-I)	College Research Council	The effect of extracorporeal shockwave therapy on cytokine and prostaglandin concentration within synovial fluid following intra-articular injection with platelet-rich plasma	7/1/24-6/30/25	$24,584
Lauren Smanik (PI)	Arthrex	CSU ACP Max Bone Study: AIRR-0247	11/27/23-5/31/26	$40,730
Melinda Story (PI), Kelly Santangelo (Co-PI)	College Research Council	Exploring the dorsal root ganglia in a naturally occurring model of osteoarthritis	7/1/23-6/30/24	$25,000
			TOTAL	$7,992,307

The Orthopaedic Research Center at Colorado State University is known worldwide for joint problem prevention and healing research in horses, with complementary work in human athletes. We are at the forefront of developing novel therapies, including stem cells that offer exciting treatment options for neuromusculoskeletal disease and injury.

Your gift to the ORC will advance our research program, support innovation in clinical treatments and regenerative therapies, and advance translational research. If you have more questions about giving opportunities at the ORC, please contact Assistant Vice President of Advancement, Sarah Schmidt, at *cvmbs-giving@colostate.edu*.

You can also give online at

advancing.colostate.edu/ORCE

Learn so much more about the ORC online at

vetmedbiosci.colostate.edu/orc

Dr. Chris Kawcak and "Amelie"