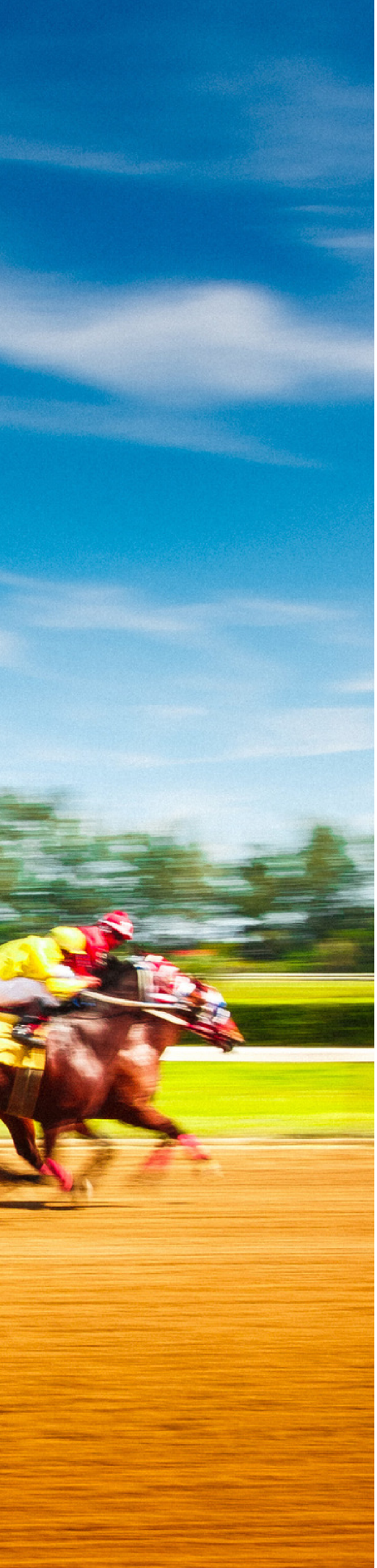
Setting the Pace

SVM researchers on track to revolutionize racehorse safety

By Gian Galassi



WHILE WATCHING AUSTRALIA'S FAMED MELBOURNE CUP, SVM PROFESSOR PETER MUIR CAN'T HELP BUT FEEL LIKE HE HAS A HORSE IN THE RACE. IN SOME WAYS YOU COULD SAY HE HAS MANY.

Dubbed "the race that stops a nation," the Melbourne Cup has long been the most popular Thoroughbred horse race in Australia, but a troubling number of highly publicized racehorse deaths before 2021 resulted in public outcry and increased scrutiny of Racing Victoria, the governing racing authority that manages the Melbourne Cup and its Spring Carnival of races. In response, Racing Victoria introduced a bold new pre-race screening protocol in 2021 designed to improve the health and welfare of the racehorses. Among the safety measures they implemented were mandatory pre-race scans of racehorses ahead of the Melbourne Cup using a standing CT machine, an advanced imaging modality first imagined by Muir in 2005 while he was doing research on equine stress fractures in his lab at the UW School of Veterinary Medicine. The objective of the new protocol is to better identify hors- es that have an increased imminent risk of experiencing catastrophic injury or death from stress fracture if they are allowed to race. So far, the program seems to be working. In the three years since Racing Victoria implemented mandatory pre-race standing CT scans, there has not been a single catastrophic equine injury or death during the Melbourne Cup race.

PHOTO: SUBMITTED BY PETER MUIR

Peter Muir, co-director of the SVM Comparative Orthopaedic Research Laboratory

While improved equine safety at the Cup has been validating for Muir, he knows there's still a lot of work to do before the technology becomes broadly accepted by the racing industry worldwide. But with each new scientific study that he and his colleagues publish about the benefits of using standing CT imaging as a pre-race screening tool, the closer he gets to proving that the beneficial impact of standing CT imag- ing, which once felt like little more than a longshot, is now a legitimate frontrunner to solve one of horseracing's most vexing problems.

Out of the Gate

Muir's initial idea for the standing CT machine, more formally known as a standing helical computed tomography scanner, evolved for years before finally becoming a reality. As an orthopaedic surgeon and internationally recognized scholar on musculoskeletal injuries in racing greyhounds and horses, Muir first realized back in 2005 that standing CT equipment would be a transformative advance in equine veterinary medicine and, if designed appropriately, would be cost efficient, effective, safer to use, and diagnostically more powerful than what was currently available at the time. Based on his stress fracture injury research, he also knew that if this new modality could be used for detection of early injuries that might lead to catastrophic equine injury and death, it would be highly impactful to the sport of Thoroughbred horse racing as well.

"I had just published my first research paper on equine stress fractures when I started thinking about what might be possible with a more robust diagnostic imaging tool," recalls Muir, who today co-directs the Comparative Orthopaedic Research Laboratory at the School of Veterinary Medicine. "It was obvious that what the industry needed was a technology that eliminated the barriers that made imaging of large animals so complicated, which meant it needed to be less risky for patients and providers, and far more accessible and cost effective."

What he imagined was a CT machine in which horses could be scanned while they were under light sedation and standing upright, which for the first time would allow veterinarians to obtain accurate imaging of the structural problems in horses' legs while they were bearing the full weight of their body, something the best technology couldn't do.

As with most medical innovations, it took some time for Muir's idea to evolve from a promising concept to a viable possibility. To bridge that gap, Muir collaborated with Professor Rock Mackie in 2013, then director of medical engineering at UW's Morgridge Institute for Research and co-founder of TomoTherapy®, the radiation-based cancer treatment machine that's now commonly used in human medicine. Mackie's medical physics expertise and entrepreneurial spirit proved invaluable to the project, as did the input and expertise from current SVM Dean and equine orthopaedic surgeon Mark D. Markel and UW adjunct Professor of Medical Physics David Ergun. Over the next several years, the four of them further refined the concept of the standing CT technology and worked with the Wisconsin Alumni Research Foundation (WARF) to help bring their product to market.

In 2015, the company Asto CT was born, and Muir's brainchild, now more than 10 years old, finally got a name: Equina®. At the time, it was the world's only standing helical CT scanner on the market that could vertically scan the lower legs of a standing, sedated horse as well as move horizontally to scan the head and neck, three areas of the body where CT is particularly beneficial to large animal veterinarians. Since then, the Equina® standing CT system has proven very useful for the non-racing equine community, filling a longstanding, unmet need in the diagnosis and treatment of conditions facing other large animals as well, including head and neck tumors and diseases of the feet, teeth and sinuses.

But for the Equina® standing CT System to fulfill the original mission of improving the health and safety of racehorses, Muir has been doing what he does best: letting science take the lead in demonstrating how the technology benefits not only animal welfare but the welfare of the sport's various stakeholders as well.

Susannah Sample, principal investigator in the SVM's Comparative Orthopaedic Research Laboratory, works on an early prototype of a standing CT gantry in 2005.

Rounding the Turn

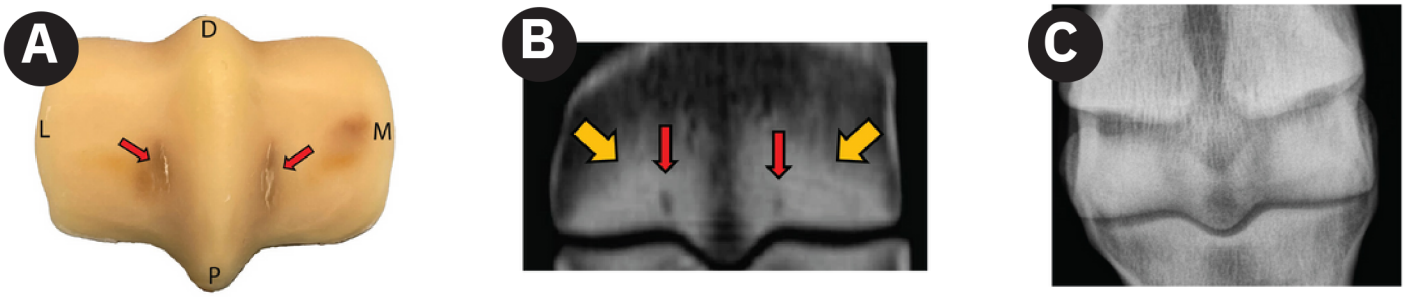
Like a jockey who initially keeps their horse from running at top speed, Muir is not yet ready to definitively say the Equina® standing CT System is or should be the leading tool in pre-race injury risk assessment. Before he can, Muir and fellow researchers need to answer one of the racing industries most pressing questions: can standing CT technology reliably predict which horses should be scratched from a race due to a high risk of catastrophic injury and which ones are healthy enough to run?

"Any effective screening test designed to prevent acute, potentially catastrophic injuries should be highly sensitive (produce few false negatives) at identifying at-risk horses so that racetrack veterinarians can be confident when they clear a horse to race" says Muir. "But test specificity (few false positives) is equally important, because the Thoroughbred racehorse industry will not accept a screening test that allows many healthy horses to be removed from racing if they ultimately don't need to be."

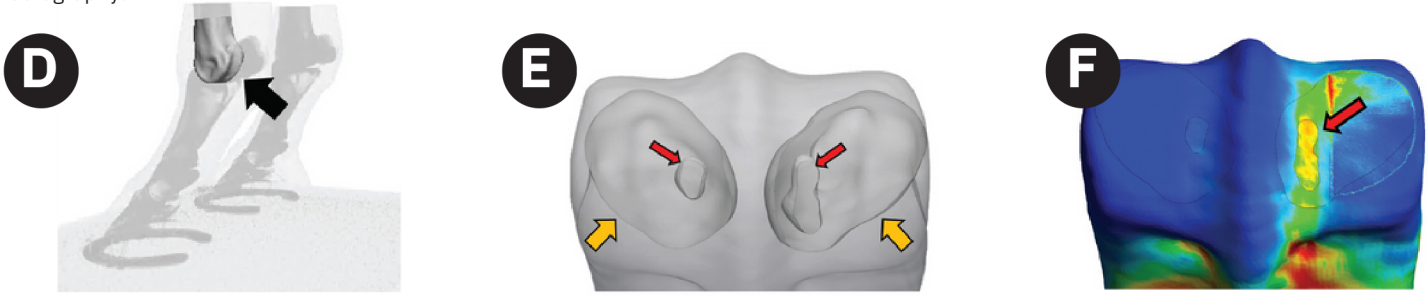
To address the issue, Muir designed a study a couple years back to determine the sensitivity, specificity, and reliability of using standing CT imaging to assess the risk of condylar stress fracture, an orthopaedic injury often associated with race-related injury and death. The goal was to compare the diagnostic metrics of standing CT technology to the use of digital radiography, the most commonly used imaging modality to assess injury risk in racehorses today.

The study itself was relatively straightforward. Muir and his team recruited four "observer" veterinarians with extensive experience with equine orthopaedic imaging to examine a blinded set of digital radiographs and standing CT images of the lower legs of 31 Thoroughbred horses that died or had to be euthanized during training or racing activities. Based on the images they examined, each veterinarian was then asked to assign a risk assessment grade to indicate how likely the changes they saw in the horses' fetlock (the part of the leg that most closely resembles a human ankle) would result in elevated imminent risk of catastrophic stress fracture. Their diagnostic predictions were compared to a reference assessment to determine sensitivity and specificity, and then compared to each other's observations to determine reliability and repeatability of their predictions—important metrics for determining how useful the imaging methods would be for pre-race screening. Some of the most salient results of the study, which were published last fall on the preprint server BioRxiv, demonstrated that sensitivity of risk assessment was better with standing CT technology than with digital radiography, particularly for horses with elevated risk of injury. However, the study also made it clear that although standing CT technology makes it easier for veterinarians to find problematic bone lesions, there remains uncertainty in veterinarians' ability to determine from those images which horses' injuries have reached a critical threshold of mechanical compromise. And that

Diagnostic imaging and virtual mechanical testing of the cannon bone of a Thoroughbred racehorse with a high degree of fatigue damage.



A) Photograph of the joint surface after removal of the articular cartilage shows parasagittal fatigue cracks (red arrows). B) Standing CT imaging has a higher sensitivity for capturing the parasagittal fatigue damage (red arrows) and the surrounding dense bone (orange arrows) than C) digital radiography.



D) The standing CT images are used to make a 3D model of the cannon bone with E) segmentation of sites of fatigue damage and the surrounding adaptive response shown with red and orange arrows respectively. The surrounding bone becomes more dense (orange arrows) in response to race training. F) Virtual mechanical testing of one of the condyles shows concerning parasagittal groove strain concentration (red arrow), suggesting elevated risk of serious injury during racing because of mechanical compromise to the bone.

uncertainty does not yet provide an acceptable level of accurate risk assessment that's required for an optimal pre-race screening tool.

"The connection between structural change in the bone and mechanical compromise is one of the most important gaps in knowledge right now," says Muir. "And it's a gap that has to be filled so veterinarians tasked with determining the fitness of Thoroughbred horses to race can make a more appropriate risk assessment of how compromised the bones really are, especially as more research on the topic gets published."

Muir and his team are currently addressing this gap in knowledge through research that will develop a validated 3D finite element computer model of the equine cannon bone built from CT imaging. Virtual mechanical testing can then be performed using computer software to look for mechanical compromise in the bones from individual horses. With more work, this assessment approach will enable veterinarians to optimally and objectively analyze CT scans in a manner that would be suitable for clinical implementation. This work is being done in collaboration with Corinne Henak from the UW Department of Mechanical Engineering.

PHOTO COURTESY OF CHRIS WHITTON, UNIVERSITY OF MELBOURNE

A Thouroughbread horse gets a standing CT scan of its front limbs at the University of Melbourne in Australia.

It's a complex orthopaedic problem that the racing industry and horse owners will likely continue to struggle with for years to come: finding the right balance between identifying the small subset of horses that have concerning lesions from the horses that have a subchondral bone injury lesion, but are ultimately doing ok. Muir says that even the most sophisticated technology will likely never completely resolve the issue, which further underscores a major ethical paradox facing racetrack authorities and racehorse owners.

"Nobody wants any of these horses to suffer injuries or die, of course, but they also want them to race and win a million dollars."

So what can be done? For one thing, Muir says more peer reviewed science is crucial, as is making more information available to help guide clinicians to better identify horses whose bone injury puts them at imminent risk of catastrophic injury. To aid in that effort, Muir and his research team publicly released the blinded image set they used in their study so that other clinicians and researchers around the globe can use them to either train their veterinarians or conduct additional studies on the topic. After all, science at its best is a team sport, and Muir believes strongly in not only learning from but empowering researchers around the globe to work collaboratively toward improved equine safety.

"I see this not only as the basic advancement of knowledge, but also an example of the Wisconsin Idea in action, which strives to make societal progress at the broadest level."

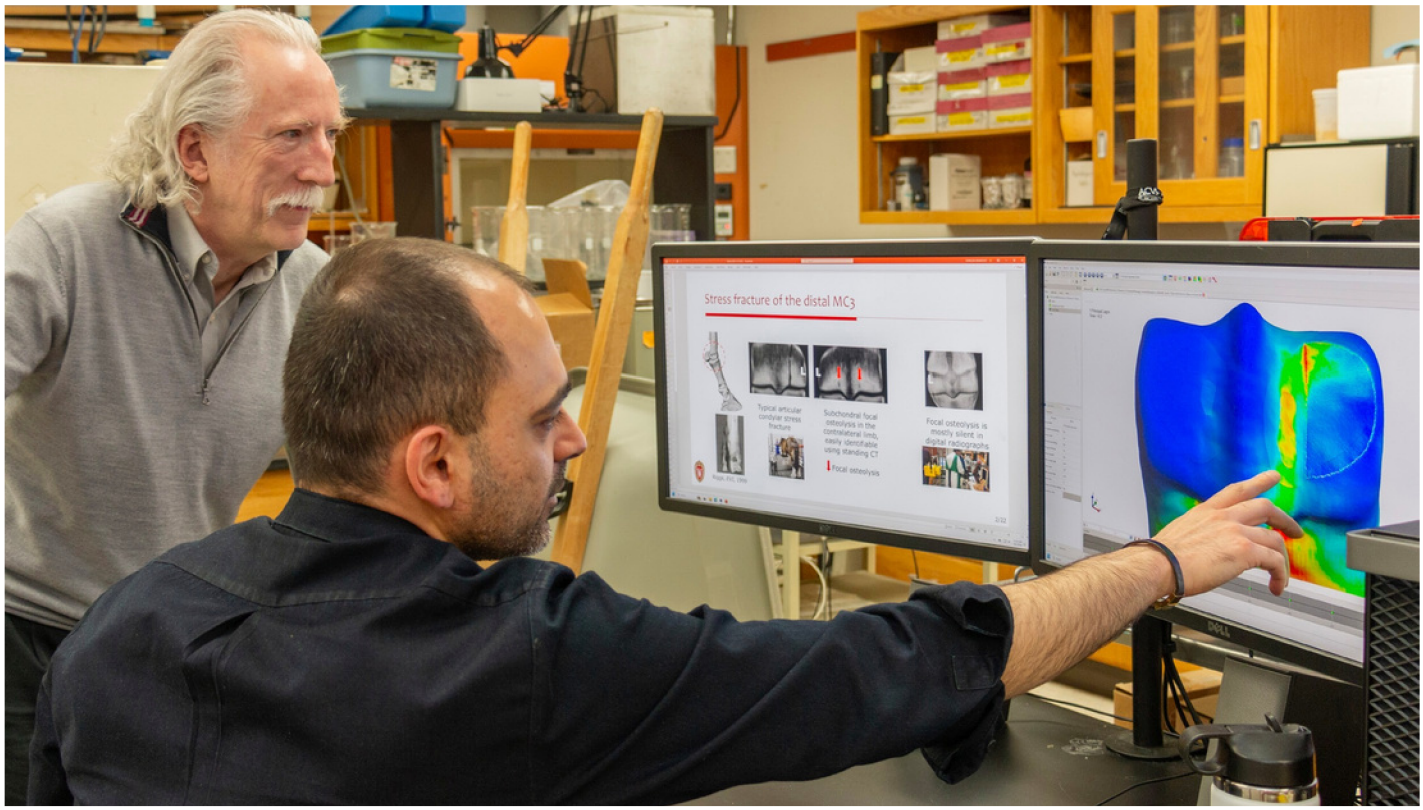
Down the Stretch

A recent review of racehorse deaths by the Horseracing Integrity and Safety Authority (HISA) found that the rate of equine deaths at racetracks in their jurisdiction is at a 10-year low, but intense media coverage of race-related deaths has dominated the headlines of late, overshadowing their otherwise optimistic news. In 2022, the incidence of catastrophic injury was 1.25 fatalities per 1,000 race starts in the United States, which represents a loss of hundreds of horses. That number was slightly better in 2023, but it included the highly publicized death of 12 horses at Churchill Downs, including seven in the run-up to last May's Kentucky Derby, and 13 at Saratoga Race Racetrack, home of the Belmont Stakes, the third leg of racing's triple crown. Many of the deaths were the result of musculoskeletal injuries.

Taking a somewhat similar approach to what Racing Victoria did when facing comparable scrutiny, racing authorities in the US last year strengthened their own equine safety and race policies, none of which, however, include the use of standing CT technology or mandatory scans for finalists.

"If finalists in the Kentucky Derby and other major races had pre-race standing CT scans assessed by a panel of skilled reviewers, would that have had an impact on what happened last year?" asks Muir. "Based on extrapolations from what we've learned so far from the Melbourne Cup, I think it would."

As the industry continues to endure public scrutiny regarding equine health and welfare, particularly when a cluster of deaths occur, racing advocates and veterinarians alike are starting to question whether it makes sense anymore to delay mandatory pre-race screenings, using standing CT or similar technologies, until more comprehensive evidence exists.



SVM Professor Peter Muir (left) and Research Associate Soroush Irandoust review an image of the cannon bone of a Thoroughbred racehorse.

"If you are a racing authority or racetrack owner, I think it would be imprudent to ignore the increasing scrutiny and pressure that comes from negative public perceptions of the sport," says Muir. "Our existing knowledge has evolved quickly over the last few years, and although we still have a way to go, I think a lot of people are really starting to take notice what's been happening at the Melbourne Cup."

Like any good scientist, Muir champions the role of science and the value that additional research will bring to the debate, but now believes that perhaps the most pragmatic and efficient path forward would be for the racing industry to use all available data to them and implement pre-race screening sooner than later, while working to fill the gaps in knowledge with ongoing and robust peer-reviewed science.

Toward that end, Muir was recently awarded grants from the Hong Kong Jockey Club Equine Welfare Research Foundation and the Grayson-Jockey Club Research Foundation to extend his research program on the use of standing CT and computer modeling analysis to predict risk of fetlock stress fracture. Going forward, Muir and his team will also focus on stress fracture of the proximal sesamoid bone, another common cause of fatal injury in Thoroughbred racehorses. This new research will advance understanding of the relationship between specific structural changes in the proximal sesamoid bone and imminent risk of stress fracture, further improving longitudinal monitoring of horses in training and reducing catastrophic injury during races.

Eyeing the Finish Line

For Muir, the improved health and welfare of racehorses is the ultimate victory, and he's confident that the impact of his research on the issue, along with that of his academic collaborators, colleagues, and fellow researchers, will only continue to grow as does the mounting body of scientific evidence. There's no doubt the Melbourne Cup's achievement of zero equine fatalities since 2021 represents a turning point in the world of horse racing, one that Muir and others hope is an inspiring example for the rest of the global horse racing community to follow.

Until then, Muir can't help but feel like the finish line is in view.

"Bringing innovation to bear on issues impacting the world in various way is, of course, just one of the things that sets this university apart from its peers," says Muir. "And that's certainly been true from my point of view. I don't think this interdisciplinary project, or the subsequent benefit to animal welfare, would be a reality right now had I worked at any other university or veterinary school".