Final Report **Summary**

Computational modelling of limb loads from galloping horses on different tracks

August 2018 – April 2020

AgriFutures® Thoroughbred Horses

Objectives

The objective of this project was to develop a deeper understanding of track surface properties that affect limb loads in galloping horses.

To achieve this, we aimed to:

- **Collect motion data in three dimensions of three thoroughbred racehorses galloping on a treadmill, and on sand and synthetic racetrack surfaces**
- **Create computer models of a treadmill surface and two different racetrack surfaces (sand and synthetic)**
- **Combine the motion data sets with the track surface models into a full-body computer model of a galloping horse.**

Background

The high loads generated in horses' limbs during galloping cause deterioration of bone, cartilage, tendons and ligaments. This process is the most common cause of muscle, joint and bone injuries in racehorses. The amount of tissue damage caused by galloping depends on two factors – the size of the load generated in the limbs during each stride, and on the number of times the load is applied. It is difficult to accurately measure and evaluate such loads in a galloping horse, so there is little data about it, despite its importance as a cause of injury. With the previous support of AgriFutures Australia, we developed the most comprehensive and scientifically accurate simulation of the equine forelimb thus far. This model has enabled us to measure loads in horses walking, trotting and cantering on a treadmill. It has also been used to estimate loads in the forelimb of horses galloping on racetracks in the USA, but not in Australia. This model has one important limitation – it does not allow a comparison of the effects of changing the properties of a track surface. This is because, with any change, motion data must be collected again. Our current proposal will overcome this limitation. The racing industry invests in racetrack surfaces without evidence-based information about how their choice might influence the load on the limbs of galloping horses, and the consequent risk of injury. To develop safer track design, it is essential that we have methods to help us understand how track surface properties affect loading within the limbs of horses.

Results

Computer models of two track surfaces (sand and synthetic (Polytrack®)) and a treadmill surface were developed and calibrated against track testing devices. These devices drop a weight onto the surface to test impact properties, then drag the weight across the surface to test shear properties. These models were good predictors of the mechanical properties of real tracks.

The mechanical testing showed the treadmill surface is substantially stiffer than both racetrack surfaces. The sand track has a softer initial impact response than the synthetic track, but the maximum impact force is larger. The sand track is also much stiffer on a second impact at the same site. This is due to compaction of the material. By contrast, the synthetic track is more consistent over multiple impacts.

Motion-capture data was obtained from three horses galloping on different surfaces: a treadmill, a sand track, and a synthetic track. Software for calculating the movements, loads, and forces generated by the muscles was developed using the CSIRO Workspace platform. Then the locomotion of one racehorse on each of the three different surfaces was measured. The horse wore markers that were recorded when the horse galloped at racing speed. This data was used to create a full body model, or simulation, of a galloping horse. This model was combined with the track surface model to calculate the vertical force between the hoof and ground surface.

The vertical forces on the forelimb were highest for the treadmill, intermediate for the sand, and lowest for the synthetic track. Because these surfaces have different mechanical properties, this outcome was expected. But the differences in loads on the limb produced by each surface was less than forecast. This indicates that horses adjust their gait to reduce the effect of surface stiffness.

Outcomes

Three-dimensional full-body motion datasets were collected for three thoroughbred racehorses galloping at different speeds on a treadmill, and on sand and synthetic racetracks. The mechanical properties of three surfaces (treadmill, sand and synthetic) were tested. Computer models of these surfaces were created and calibrated with the testing data. A full-body computer model of a galloping horse was developed from the data derived from a single horse galloping on a treadmill, and on sand and synthetic tracks. This model enabled measurement of forces on the limbs. It showed that the synthetic track had the lowest limb loads.

For future work, simulations using data from all three horses and the modelling framework developed in this project will continue. This will confirm whether the single horse response observed in this study is similar in other horses. Using the models developed in this study, we can investigate how changes in track surfaces affect galloping horses. Importantly, we can do it without having to collect more data from live horses on real tracks. From this, a deeper understanding of two things is expected to follow:

- How horses modify their gait for different surfaces.
- How modifications to track surface properties could reduce loads in the joints, tendons & bones.

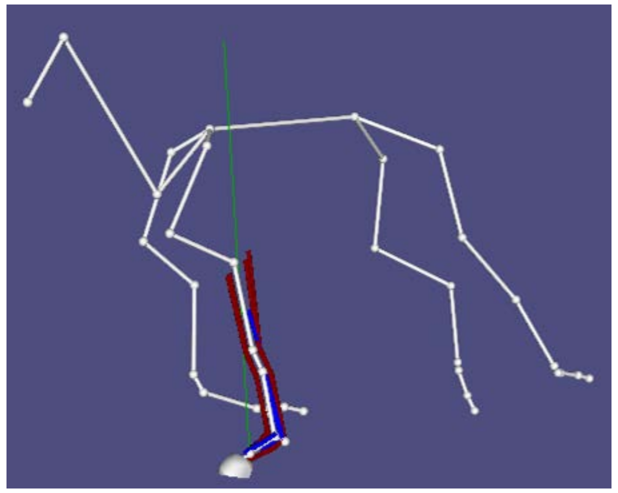

Figure 1 Simulation

Implications

Loads in limbs of galloping horses arise from a complex interaction between two factors: the mechanical properties of a track surface, and the way a galloping horse moves in response to those properties. Horses are able to limit the effect of stiffer track surfaces by changing the way they move; however, synthetic tracks generate lower loads in the lower limb than sand tracks. Therefore, synthetic tracks are preferred for high-speed galloping.

The tools developed in this project will enable in-depth investigation of track surface design and maintenance, and the effects on limb loads in galloping horses. The eventual goal is safer surfaces for racehorses.

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