Mathematical modelling of metacarpal subchondral bone adaptation, microdamage, and repair in racehorses

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(Major Research Grant: AUD 369,702)

Bone injuries in racehorses occur when microdamage, generated by repeated loading of the skeleton during galloping exercise, accumulates faster than the inbuilt repair mechanism of bone can remove the damage. The resultant injuries include fractures, both catastrophic and non-catastrophic and subchondral bone injuries which are common and cause poor performance, pain and lameness.

Although various risk factors for musculoskeletal injury in racehorses have been studied, they have not proven useful for early detection of injury or impending onset of conditions resulting in poor performance or catastrophic injury. And advances in diagnostic imaging have meant that pre-fracture pathology can be detected, but the widespread use of advanced imaging for the whole skeleton on a regular basis is not practical. Prevention of musculoskeletal injury through understanding how to manage a horse's workload appropriately is likely to have more universal application and therefore success. With the advent of technology that enables the accurate monitoring of galloping speed and distance, real time assessment of individual horse workloads is now achievable.

However, the relationship between workload and injury is complex with studies showing both too much and too little training and racing can lead to fracture. This is because of the complex relationships between bone adaptation, damage accumulation and damage repair. Cross-sectional studies provide excellent baseline data for understanding such complex processes but only by modelling these processes can we hope to understand and predict them accurately.

We have previously developed a mathematical model of bone adaptation in Thoroughbred racehorses that approximates existing Thoroughbred racehorse training and rest regimens where bone adapts to training after about 14 weeks, but de-adapts in response to rest much faster, in 10 weeks or less. To further develop this model, we will account for bone microdamage accumulation and its repair.

This improved model will help us to better understand the process of bone adaptation, microdamage, and repair in racehorses so that we can assess and develop training strategies that reduce the risk of racehorse injury. This method is an ethical means of assessing the biological effect of changes prior to recommending and implementing lower risk training programs to the wider racehorse trainer community.