Understanding leg fatigue fractures in Thoroughbred racehorses

In this project we examined differences in bone microstructure and metabolism between horses that suffered catastrophic fractures and those that did not. This provides baseline information for the development of clinical screening for and prevention of fracture risk among racehorses.

Catastrophic fatigue fractures of the distal limb are the most common cause of racetrack fatalities. Early detection of fatigue injury and the development of training strategies that reduce the risk of injury will therefore have a significant positive impact on the racing industry.

Who should be interested in the findings?

This report is highly relevant to racehorse owners and trainers, veterinary surgeons who treat racehorses, and racing authorities.

Background

Catastrophic fracture of the distal limb has been identified as the most common cause of racetrack fatalities in Victoria (Boden et al., 2006). The majority of distal limb fractures in racehorses are fatigue fractures that result from accumulation of damage over time (Parkin et al., 2006, Stepnik et al., 2004, Anthenill et al., 2007). Fatigue is a complex process and is influenced by a number of factors. These include the loading magnitude, the number of cycles of loading, the bone’s geometry, the presence of imperfections and the rate of bone replacement.

Bone modelling is the process in which bone adapts to its loading environment by changes in volume or shape. When loads increase bone is deposited onto internal and external surfaces resulting in an increased bone volume. Bone remodelling occurs when bone resorption is followed by bone formation and there is no net change in bone volume or shape. Bone avoids fatigue fracture by replacement through remodelling and by adapting to increasing loads through modelling.
However bone remodelling is supressed under conditions of repetitive high loading, the circumstances under which fatigue damage accumulates (van Oers et al., 2008).

Third metacarpal condylar (MC3) fractures are the most common catastrophic fracture in Thoroughbred racehorses. The MC3 adapts to high speed exercise and training by marked increases in midshaft cortical bone thickness, and thickening of trabecular and filling of trabecular spaces in the distal epiphysis (Boye and Firth, 2005). There is also evidence that in horses in training remodelling in the third metacarpal bone is suppressed (Boye and Firth, 2005, Jackson et al., 2003, Firth et al., 2005, McCarthy and Jeffcott, 1992a). Changes in training techniques are known to influence how bone models and remodels (Young et al., 1991) and therefore potentially reduce fracture rates but better understanding is required.

Riggs and Boyde (1999) proposed that modelling results in density gradients in the distal third metacarpal (MC)/metatarsal (MT) bones at the parasagittal groove, the most common site of MC/MT bone fracture. These gradients are thought to increase the magnitude of shear forces (the most damaging type of force) and therefore risk of fracture.

Focal remodelling has been observed at the site of fracture propagation but it is not known if this contributes to fracture propagation or is just an indication of high levels of bone fatigue (Riggs and Boyde, 1999, Riggs, 1999). Generalised remodelling is induced rapidly when horses are rested (McCarthy and Jeffcott, 1992b). If horses return to training with weak, porous bone then fracture risk is likely to be increased.

If bone modelling processes and their effect on injury development can be better understood through research, then the findings should be able to be translated into modifications to training practices to decrease the risk of injury.

**Aims/objectives**

By providing information on how to better manage horses to prevent a common injury this research will benefit racehorse owners and trainers, veterinary surgeons who care for racehorses, racing authorities as well as the racing industry as a whole.

**Methods used**

Third metacarpal bones from horses that died on Victorian racetracks were examined using micro computed tomography (Micro CT) and backscattered scanning electron microscopy (BSEM) to investigate adaptation and repair processes and their role in fracture development. Bones from horses with third metacarpal bone fractures were compared with those from horses in full training without any fracture, horses with a limb fracture at another site and horses resting from training.

**Results/key findings**

In horses in race training normal repair processes in the subchondral bone of the MC3 is suppressed and damage due to repeated loading accumulates at the articular surface. During rest periods remodelling is activated and the damage load is reduced. The surrounding BV/TV increases to compensate but this process appears to only delay injury rather than prevent it. This increased BV/TV can be detected with Micro CT but this change is seen in horses that fracture other bones as well. Advanced imaging techniques examining the distal MC3 by detecting horses that are overloading their skeleton may be useful for detecting horses at risk of fracture but not specifically for MC3 fractures.

**Implications for relevant stakeholders**

Injury of the distal articular surface of the MC3 in horses in race training is common and may progress to fracture which is often fatal. There is some potential for early detection of these injuries with sophisticated imaging techniques but these are unlikely to be used as widespread screening tools. Therefore methods of fracture prevention are likely to be the most effective means of injury reduction.

Equine bone has the ability to adapt to training and racing as well as repair damage that occurs. Better understanding of these processes and how they can be enhanced has great potential for injury prevention. In particular it is possible that training strategies that allow ongoing bone repair can be developed that will reduce the risk of injury. Alternatively, if this is not achievable, then investigation of the duration of a training period that minimises the risk of bone injury as well as the duration of rest periods that allow adequate repair are required.

**Recommendations**

Further investigation is required into the effect of different training strategies on subchondral bone remodelling, safe durations and intensities of training periods, and appropriate periods of rest. (continues overleaf)
In the absence of this information it is recommended that exercise intensity be increased gradually in 2-year-old horses entering training for the first time and that training periods do not exceed 6 months in duration in all horses. The development of methods of imaging distal MC3 subchondral bone in live horses is desirable. Both MRI and CT are now available although are not suitable for imaging large numbers of horses cost effectively.

Publications arising from this project

The following scientific publications describe in detail the methods and results of the research undertaken for this project. These papers may be obtained through a university library or the publisher web site for specific journals.


Cited references


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