RESPONSE OF EQUINE BONE TO EXERCISE
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Key points

- Bone homeostasis is a dynamic event that can be influenced by a number of factors
- Exercise at an early age can have a positive impact on bone strength

Ever since Dr. Julius Wolff in the 19th Century stated that bone will adapt to the loads it is placed under, scientists and clinicians began to understand that bone is a dynamic organ that is ever changing.1,2 Several studies have shown that bone modeling and remodeling responses are a means to strengthen the bone in response to increased load. In addition, several studies have also shown that the remodeling response acts to weaken the bone when the stimulus for constant loading is removed. This latter occurs commonly with immobilization whether it due to casting a limb for fracture or neurologic injury.2 In the last couple of decades several researchers have also identified that the bone modeling and remodeling responses can also reach a critical threshold in which bone damage can occur. The objective of this review is to briefly review bone modeling and remodeling responses, to review subchondral and cortical bone responses that can be damaging and to review attempts at early exercise that may strengthen the bone in the future.

Bone remodeling occurs when packets of bone are removed by osteoclastic resorption and new bone is formed by osteoblasts on the resorbed surfaces. This occurs throughout an animal’s life but does slow with maturity and age. This response can change the material properties, density and geometry of the bone over time. The key factor is that the bone formation response lags several months behind the bone resorption phase thus setting up a period when the bone is weakened and susceptible to further damage. Bone modeling occurs without a mandatory resorption phase. Bone modeling typically occurs on the surface of trabeculi usually in the proximal and distal ends of the bones and beneath the articular cartilage. This response can also induce a change in bone material properties, density and geometry of the bone.

Perturbations in bone remodeling occur commonly and lead to several diseases including osteoporosis and fatigue fracture. In osteoporosis the osteoclastic response far outweighs the osteoblastic response thus leading to weakened bone that is susceptible to fracture. In the case of fatigue injury, microdamage stimulates the remodeling response and in the face of training the bone continues to weaken.3,4 If a threshold of exercise is reached which far exceeds the bone formation phase then gross clinical fracture can occur. A threshold of bone modeling can also be reached in which subchondral bone density can become large enough to induce changes in the osteochondral tissue.5 This thickened bone can remodel into and through the calcified cartilage into the articular cartilage thus leading to articular cartilage thinning and consequently osteoarthritis (OA).

There have been several attempts to strengthen bone by imposing early exercise in young horses.6-8 Several studies have shown that foals that are given turnout exercise as opposed to stall rest will have significantly superior bone properties and significant decrease in developmental orthopaedic disease.8 Further studies went on to show that imposition of early exercise in Thoroughbreds led to increased bone formation. However, in the latter study a decrease in clinical incidence of disease was not seen compared to controls.
The use of exercise to stimulate a bone response must be done carefully and with close management. As an example, Tull and Bramlage used free choice exercise to induce repair of incomplete condylar fractures in Thoroughbred racehorses. This type of exercise is beneficial since the turnout exercise is self-regulated by the horse and is unlikely to reach levels that induce fatigue injury. However, there is a lack of data on imposition of controlled exercise in the adult horse and resultant changes in bone. It is likely that exercise in the adult will lead to maintenance of muscle strength and axial loading which can maintain bone mass however, imposed exercise must be done carefully so as to not worsen any joint or soft tissue injuries that may exist.

In summary, in the young horse exercise induces a significant remodeling and modeling response in bone. Maintenance of that bone content requires further exercise however, below a critical threshold at which exercise can induce disease.

1. Wolff, J. Das Gesetz der Transformation der Knochen. Berlin: A Hirschwald (Springer-Verlag published an excellent English translation of this monograph in 1986); 1892