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DO OSTEON POPULATION DENSITIES REFLECT DIFFERENCES IN FATIGUE HISTORY BETWEEN LIMB BONES OF CURSORIAL MAMMALS?

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It has been suggested that limb bones of cursorial mammals are optimized for mechanical/energetic efficiency as oscillating pendulums. Consequently, morphologies of limb bones and their associated soft tissues are highly constrained by kinetic/spatial demands, including accommodating stress transfer, enhancing stride length, and minimizing energetic "costs" of adding mass (i.e., maintaining tapered limbs). Optimization theory suggests that weight-bearing strains are highest in distal bones (i.e., nearest the point of impact) and progressively decrease proximally. Investigators have speculated that fatigue microdamage would be most prevalent distally. Since BMUs repair microdamage, limb bones of a cursorial animal should exhibit a distal-to-proximal decrease in population densities of secondary osteons. In turn, between-bone differences in microdamage would not be expected in mature animals. To test these hypotheses, fresh skeletons of 11 wild mature male mule deer were collected and mid-diaphyseal transverse segments were cut from the left proximal phalanx of the medial digit, principal metacarpal, radius, and humerus. A 100micron slice was obtained from each bone of 7 animals, and was used to determine population densities (no./mm^2) of secondary osteons and new remodeling events (NREs = resorption spaces and newly forming osteons). An additional 10-to-16mm section obtained from each animal was stained in 1% basic fuchsin and examined by 3 observers for in vivo microcracks (3 slices/bone, 165 total slices). Results of osteon density measurements demonstrate [means and (standard deviations)]: phalanx [10.2 (2.2)], metacarpal [5.9 (2.5)], radius [8.7 (3.0)], and humerus [2.5 (1.9)]. Only two microcracks were identified, and these were found in the radius of one animal. Variations in NREs did not demonstrate progressive differences and were not significant between bones. Absence of significant between-bone differences in microcracks and NREs suggests that these bones are, respectively, adapted for fatigue requirements and in remodeling equilibrium. However, these data fail to demonstrate a progressive distal-to-proximal decrease in osteon density. At high gait speeds, eccentric loading, and energy storage and stress transfer associated with musculotendinous structures may result in relatively lower strains in some distal bones (e.g., metacarpal < radius). Consequently, a progressive distal-to-proximal strain gradient may not occur during gait speeds that most commonly produce microdamage.