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Strain rate dependency of bovine trabecular bone under impact loading at sideways fall velocity

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Abstract

There is currently a knowledge gap in scientific literature concerning the strain rate dependent properties of trabecular bone at intermediate strain rates. Meanwhile, strain rates between 10 and 200 /s have been observed in previous dynamic finite element models of the proximal femur loaded at realistic sideways fall speeds. This study aimed to quantify the effect of strain rate ($\dot{\varepsilon}$) on modulus of elasticity (E), ultimate stress (σ_u), failure energy (U_f), and minimum stress (σ_m) of trabecular bone in order to improve the biofidelity of material properties used in dynamic simulations of sideways fall loading on the hip. Cylindrical cores of trabecular bone (D=8mm, L_{gauge}=16mm, n=34) from bovine proximal tibias and distal femurs were scanned in µCT (10µm), quantifying apparent density (ρ_{app}) and degree of anisotropy (DA), and subsequently impacted within a miniature drop tower. Force of impact was measured using a piezo-electric load cell (400kHz), while displacement during compression was measured from high speed video (50,000 frames/s). Four groups, with similar density distributions, were loaded at different impact velocities (0.84, 1.33, 1.75, and 2.16 m/s) with constant kinetic energy (0.4J)