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The "Shear Resistance-Priority Hypothesis": A Means for Enhancing Understanding of Material Adaptations in Bones that Habitually Experience Complex Loading

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In anthropological studies of cortical bone adaptation in limb-bone diaphyses there is an unrecognized bias — the bones examined are often habitually/stereotypically subjected to complex loading. Consequently, bone matrix adaptations can be difficult to interpret because complex loading engenders prevalent/predominant shear strains. Of the three strain modes (shear, tension, and compression) shear is potentially most deleterious (bone is strongest and more resilient in compression). Non-uniform strain distributions in cortical bone, whether produced by bending or combined bending/torsion, are an essential consequence of a bone's function because they are linked to predictability of load and nutrient delivery. One solution for the regional prevalence/predominance of tension and compression in generally exclusive regions in habitually bent bones is the formation of strain-mode-specific osteon morphotypes and/or predominant collagen fiber orientation (CFO). If, however, a bone is loaded primarily in torsion, then clear regional variations in histomorphological adaptations for these 'conventional' strain modes do not occur. This is because in limb-bone diaphysis loaded in habitual torsion there are no significant regional disparities in strain modes. The prevalent/predominant mode in torsion is shear; by the adult stage, the adaptation for this mode might be seen as relative greater uniformity in matrix organization when compared to bones that experience habitual bending with little torsion (e.g., CFO is relatively more uniform across the entire bone cross-section). Because this is not intuitive, we recommend considering the "shear resistance-priority hypothesis", which helps in understanding how a bone might adapt at the material level when the strain milieu has prevalent/predominant shear.