Signals of Locomotion and Manipulation in the Internal Trabecular Bone Structure of Extant Hominoids and Fossil Hominins

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The enhanced dexterity of the human hand is unique among primates, an ability that is traditionally thought to have evolved in response to tool-related behaviors and a release from the biomechanical constraints of locomotion in our bipedal hominin ancestors. However, recent fossil and archaeological evidence, as well as novel analyses, suggest that dexterity-related morphology and abilities evolved earlier than traditionally thought and that fossil hominins used their hands for locomotion until much later than presumed. Behavior evolves faster than morphology, and it is not yet clear how these different functional demands were potentially accommodated within the morphology of the hominin hand. We aim to improve our understanding of how our fossil ancestors used their hands for both locomotion and manipulation through the investigation of plastic aspects of bone morphology–internal trabecular (cancellous) bone–that can better reflect behaviour during life than external morphology alone. We interpret variation in trabecular structure, focusing on metacarpals, within a comparative great ape context via pressure analyses of bonobo (Pan paniscus) arboreal locomotion and human tool-use. We then incorporate these bio-mechanical data into validated musculoskeletal models of the bonobo and human third digit to estimate in vivo metacarpophalangeal joint loads. Finally, using micro FE-based inverse bone remodeling, we demonstrate how metacarpal trabecular structure reflects differences in joint loading across great apes, which can ultimately inform our reconstructions testing if and how different fossil hominins used their hands for both tool use and climbing.

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