Poster Presentation Number 51, Session 2, Thursday 2:15-3:15 pm

Inferring hand use in *Australopithecus sediba*: Analysis of the external and internal morphology of hominin proximal and intermediate phalanges

Samar M. Syeda[1], Zewdi J. Tsegai[2], Christopher J. Dunmore[1], Marine Cazenave[1], Matthew M. Skinner[1,2,3], Tracy L. Kivell[1,2,3]

1 - Skeletal Biology Research Centre, School of Anthropology and Conservation, University of Kent, Canterbury, UK · 2 - Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 3 - Centre for the Exploration of the Deep Human Journey, University of the Witwatersrand, Johannesburg, South Africa

The evolution of hominin hand use is characterized by a transition from locomotion to primarily dexterous hand use. However, this transition remains unclear with discoveries of hominin hand fossils evidencing a diverse range of manual behaviors. The almost complete right hand of *Australopithecus sediba* (1.98 Ma) shows a unique mix of primitive and derived morphology; an exceptionally long thumb and broad distal phalanx suggest human-like manipulative abilities, while curved phalanges and well-developed flexor sheath ridges (FSRs) on the proximal and, unusually, intermediate phalanges, suggest the continued importance of arboreality [1]. We used microCT scans to analyze the external and internal morphology of the non-pollical proximal and intermediate phalanges in *Gorilla gorilla* (N=12), *Homo sapiens* (N=14), *Pongo pygmaeus* (N=17), *Pan* sp. (N=18), and *A. sediba* (MH2). We quantified the degree of curvature via included angle [2], and variation in FSR morphology via linear measurements. We also assessed the cross-sectional cortical bone properties throughout the shaft using BoneJ [including cross-sectional area, polar section modulus (Zpol), and polar second moment of area (J)][3] and mapped variation in cortical thickness using Morphomap [3].

Results reveal curvature in the proximal and intermediate phalanges is lowest in *Homo* followed by, in an increasing order, *Gorilla*, *Pan*, and *Pongo*. The proximal and intermediate phalanges of *A. sediba* have intermediate values of curvature, falling within the African ape range, exceeding mean values of *Gorilla* and falling below mean values of *Pan*. After controlling for size, *Gorilla* has the shortest (in length) but the most prominent (deepest) and widest FSRs and humans FSRs are short, lacking depth and width, while *Pongo* and *Pan* share morphology that is longer but intermediate in width and depth, for both proximal and intermediate phalanges. In *A. sediba*, the proximal phalanx FSRs are most similar to *Gorilla*, but longer, while the intermediate phalanges are distinct in having proximal phalanx-like morphology, such that they lack a median bar, and possessing FSRs that are deeper than the mean values of each extant species.

The cortical bone analysis indicates that *Gorilla* has the highest values across all cross-sectional properties while humans have the lowest, and *Pongo* and *Pan* are intermediate, for both the proximal and intermediate phalanges. *A. sediba* is characterized by low cross-sectional values similar to those observed in humans. Initial bone distribution analysis demonstrates that cortical bone is thicker palmarly in great apes and dorsally in humans, in both intermediate and proximal phalanges. Consistent with the human-like CSG properties, *A. sediba* also has a thicker cortex dorsally. The low CSG properties in the fingers of *A. sediba* indicate limited strength compared to great apes, which may suggest its hands were not adapted for high loads incurred upon the hand during climbing or suspension. However, this internal structure is combined with African ape-like curvature, which provides better distribution of the stress experienced during suspension [5], and prominent FSRs, which help reduce strains on the shaft of the phalanges [5]. Thus, the external morphology of the *A. sediba* phalanges indicate a hand uniquely adapted for arboreal locomotion but one that lacked the cortical robusticity of extant great apes. This suggests that either arboreal behaviors may not have constituted a large a part of the *A. sediba* locomotor repertoire, or that the mechanical loads of this behavior were resisted in a manner different to great apes, or some combination of both.

For access to specimens we thank the following individuals/institutions: Max Planck Institute for Evolutionary Anthropology (C. Boesch, J-J. Hublin); Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science (F. Mayer, C. Funk); Powell-Cotton Museum (I. Livne); Royal Museum for Central Africa (E. Gilissen); University of Florence (J. Moggi-Cecchi, S. Bortoluzzi); Johann-Friedrich-Blumenback-Institute for Zoology and Anthropology, Georg-August University, Goettingen (B. Grosskopf); Frankfurt Senckenberg Museum (V. Volpato); University of the Witswatersand (L. Berger, B. Zipfel); Science Academy of the Czech Republic (J. Svoboda). This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 819960).

References: 1] Kivell, T. L., Kibii, J. M., Churchill, S. E., et al., 2011. *Australopithecus sediba* hand demonstrates mosaic evolution of locomotor and manipulative abilities. Science, 333(6048), 1411-1417. [2] Stern Jr, J. T., Jungers, W. L., & Susman, R. L. 1995. Quantifying phalangeal curvature: an empirical comparison of alternative methods. AJPA, 97(1), 1-10. [3] Doube, M., Kłosowski, M. M., Arganda-Carreras, I., et al., 2010. BoneJ: free and extensible bone image analysis in ImageJ. Bone, 47(6), 1076-1079. [4] Profico, A., Bondioli, L., Raia, P., et al., 2021. morphomap: An R package for long bone landmarking, cortical thickness, and cross-sectional geometry mapping.AJPA, 174(1), 129-139. [5] Nguyen, N. H., Pahr, D. H., Gross, T., et al., 2014. Micro-finite element (μFE) modeling of the siamang (Symphalangus syndactylus) third proximal phalanx: the functional role of curvature and the flexor sheath ridge. J Hum Evol, 67, 60-75.