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Comparing the trabecular structure of distal tibiae in extant hominid taxa: potential for inferring locomotor behaviour

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The ankle joint, given its proximity to the substrate and its contribution to the dissipation of ground reaction forces, is potentially a functionally informative site for analysis of internal bone structure. As trabecular bone (re)models during an individual's lifetime in response to mechanical loading, the internal structure of the skeleton has the potential to reveal how an individual behaved. A relationship between cortical and trabecular bone structure and habitual loading in humans and chimpanzees has previously been found at the ankle joint [1], potentially yielding valuable insights for reconstructing locomotor behaviour in fossil hominins. In this study we extend this work to examine trabecular bone structure in *Gorilla* and *Pongo*, to improve our understanding of the relationship between loading and trabecular structure at the ankle in extant taxa.

We analyse distal tibia trabecular structure in extant hominids with different locomotor repertoires, to investigate the link between internal bone structure and habitual loading: *P. troglodytes verus* (N=22), *G. gorilla gorilla* (N=11), *Pongo* spp. (N=6), and *H. sapiens* (N=6), scanned using micro-CT and segmented with the MIA-clustering algorithm [2].

To analyse the trabecular structure of the distal tibiae, we adopted a holistic morphometric approach using an in-house script for medtool, which segments the cortex, trabecular bone, and the internal bone cavity and air by applying several morphological filters and arithmetic operations [3]. Mean trabecular values of bone volume fraction (BV/TV), degree of anisotropy (DA), and other standard trabecular parameters were quantified throughout the entire distal epiphysis. Morphometric maps of the distribution of BV/TV and DA throughout the distal tibia were generated.

Modern humans were found to have lower BV/TV values compared to great apes, which generally had a more robust trabecular bone structure. Mean values and distribution patterns of DA were comparable among all taxa. Gorillas and humans have lower Tb.N values and higher Tb.Sp and Tb.Th values than chimpanzees and orangutans. Supporting the results of the previous study, bipedal human specimens exhibited a higher concentration of trabecular bone at the tibiotalar subarticular centre and on the medial malleolar surface, suggesting a neutrally-loaded ankle, perpendicular to the substrate [1]. In comparison, knuckle-walking chimpanzees and gorillas had higher concentrations of trabeculae at the anterolateral, anteromedial and posterocentral regions of the subarticular surface, as well as on the anteromedial malleolar surface, consistent with an ankle loaded in dorsal and plantar flexion that would occur during both knuckle-walking and arboreal climbing. Orangutans, although displaying greater trabecular bone concentration towards the anterior margin, the highest BV/TV was located anterolaterally, towards the fibular incisura, and distributed more evenly throughout the entire subarticular surface. This difference between orangutans and African apes is consistent with the more diverse postural behaviours of orangutans, and potentially higher loading at the ankle while the foot is inverted. These results demonstrate that variation in trabecular structure of the hominid distal tibia can discriminate habitual ankle posture consistent with differences in positional behaviours. These results provide the comparative background necessary for the analysis of the fossil hominin ankle posture and addressing questions on the evolution of bipedality and arboreality.

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