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Trabecular distribution of distal femur in extant apes and *Australopithecus sediba*

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Knee morphology of fossil hominins is of particular interest to paleoanthropologists due to longstanding debates about relative degrees of arboreality and terrestrial bipedalism in the hominin clade. In addition to external bone shape, the investigation of trabecular bone in the knee joint can provide insights into *in vivo* locomotor behavior of hominins [1-2]. The nearly complete right distal femur (U.W. 88-63) of *Australopithecus sediba* (1.98 Ma) shows a unique combination of condyles that resemble other australopith species and *Homo*-like anatomy of the patellar surface, which has been used to infer a unique locomotor pattern in this species [3]. Here we analyze the trabecular morphology of distal femoral epiphysis of *Homo sapiens* (N = 15), *Gorilla gorilla* (N=14), *Pan troglodytes* verus (N = 15), *Pongo* sp. (N = 9), and *A. sediba* (MH2) in order to 1) establish patterns of joint loading in extant taxa of known locomotor behaviour and 2) investigate joint loading in the knee of *A. sediba.* A canonical holistic morphometric analysis (cHMA), combining holistic morphometric analysis (HMA) and statistical free-form deformation model (SDM), approach was used to analyze the patterns of trabecular bone distribution following published protocols [4].

A principal component (PC) analysis of relative bone volume (rBV/TV) distribution shows clear separation between extant ape taxa. Positive values on PC1, PC2 and PC3 are mostly driven by rBV/TV concentrated on the patellar surface and on the posterior articular surface of the medial condyle separating humans from great apes (PC1, PC2) and chimpanzees (PC3) from humans, gorillas and orangutans. Negative PC1 is mostly driven by rBV/TV concentrated beneath the insertion of posterior cruciate ligament discriminating non-human apes from humans, negative PC2 by loadings on the patellar surface separating gorillas from others, and negative PC3 by loadings on the patellar surface and on the posterior articulation surface of the medial condyle discriminating orangutans from others. Results suggest that differences between humans and apes are primarily in the patellar articular surface.

Relative bone volume in humans is concentrated in the posteroinferior region of the lateral condyle and on the lateral patellar surface, which is consistent with loading in an extended knee position during locomotion. In non-human apes relative bone volume is found to extend from the inferior margin of the patellar articulation to the posterior region of both condyles. However, in gorillas it does not extend as posterosuperiorly in the medial condyle as it does in chimpanzees and orangutans. Trabecular bone is concentrated in the lateral condyles in apes, with the greatest values in the posterosuperior and the posteroinferior regions. Unlike humans, ape like a trabecular concentration at the distal regions of both condyles (i.e., those assumed to be loaded in an extended knee), with the lowest values in orangutans. We suggest that this reflects predominant loading in a more flexed knee posture in great apes compared to humans. Finally, among apes, we found the most homogenous distribution of trabecular bone across both condyles in orangutans, which we relate to their more variable knee joint postures during locomotion. *A. sediba* shows trabecular concentrations on the patellar surface and on the posterior area of the lateral condyle. Values in the posteroinferior and posterosuperior regions of lateral condyle are generally higher than in medial condyle. We interpret these fossil results as reflective of loading the knee joint with a degree of flexion that differs somewhat from modern humans. However, taphonomic erosion of parts of the condyles hinders a complete assessment of trabecular bone distribution in *A. sediba*.

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