Pecha Kucha Presentation, Session 2, Thursday 11:20 – 12:50

Ankle loading differences in South African *Australopithecus* and *Paranthropus robustus*

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Both external and internal morphology of the distal tibia of South African fossils presumed to belong to *Australopithecus* have been suggested to reflect a human-like loading regime, with a neutral position of the ankle joint during bipedal locomotion [1]. However, the internal bone structure of the distal tibia of *Paranthropus robustus*, and its potential locomotor signal, was unknown due to lack of relevant fossils attributed to that species. This gap in the record is now filled with the recent discovery of a complete *P. robustus* tibia (SWT1/HR-2c) from Member 1 (Hanging Remnant) of the Swartkrans Formation [2]. Here, we employ a quantitative holistic comparative approach, to characterize its internal bone structure, comparing it to tibiae StW 358 and StW 389 from Member 4 of the Sterkfontein Formation, presumed from their location to belong to *Australopithecus*. Our modern comparative sample includes the distal tibiae of 45 hominids (*Pongo*, *Pan*, *Gorilla*, as well as humans from 20th century Germany), with different locomotor repertoires and habitual loads. Trabecular bone was imaged using microCT (30-70 μm size). Bone tissues were segmented using MIA clustering [3] and trainable Weka algorithms. Canonical holistic morphometric analysis [4] was used to statistically analyse relative bone volume density (rBV/TV) within and between taxa using principal component (PC) and multivariate analyses.

Results of the PCA show a trend separating *H. sapiens*, having high rBV/TV at the centre of the tibiotalar subarticular surface, from great apes, displaying high rBV/TV in the anterolateral, anteromedial and posterocentral regions of the subarticular surface. This pattern in *H. sapiens* suggests a neutrally loaded ankle, with the tibia perpendicular to the talar trochlea. In comparison, in *Pan* and *Gorilla*, the rBV/TV pattern is consistent with an ankle loaded in dorsal and plantar flexion, which occur during both knuckle- walking and arboreal climbing. *Pongo* plots towards positive PC2 values and shows greater rBV/TV at the fibular incisura and a more homogeneous trabecular distribution across the entire subarticular surface, suggesting more diverse postural and locomotor behaviour.

Both extinct taxa display a unique set of human-like and ape-like characteristics. *P. robustus* falls within the *Gorilla* cluster with PC1 positive values. In contrast, the two presumed *Australopithecus* specimens fall in their own morphospace. This separation is driven by higher rBV/TV anteriorly and posteriorly in *P. robustus* compared to *Australopithecus*, suggesting a potentially higher load at the ankle during dorsiflexion of the foot in *P. robustus*, similar to modern African apes. While the two *Australopithecus* tibiae also show signals of this anterior concentration, they, in addition, reveal greater rBV/TV localized at the centre of the articular surface, suggesting loading in both neutral, human-like postures and in dorsiflexion typical of African apes. All extinct specimens have high rBV/TV across the articular surface in mid-sagittal view, as in *H. sapiens*.

Our results indicate that the loading environments at the ankle differed between *P. robustus* from Swartkrans Member 1 and the australopith specimens from Sterkfontein Member 4, likely resulting from different postural and/or locomotor modes. While previous evidence from the internal structure of the Sterkfontein tibiae suggested a more neutral position of the ankle and human- like joint loading [1], our whole-bone analysis suggests a more diverse locomotor repertoire in *P. robustus*. Differences between the fossil specimens support observations of the internal bone structure of the *P. robustus* and *Australopithecus* hip joint [5], suggesting these two taxa may have exploited different ecological niches.

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