Locomotor variability in Sterkfontein Member 4: Analysis of the external shape and internal bone structure of the StW 562 and StW 595 first metatarsals

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Introduction

- It remains contested whether the morphological diversity of the craniodental and postcranial hominin fossils from Member 4 of Sterkfontein can be attributed to a single taxon, *Au. africanus*[1-4].
- Variability among these fossils could be explained by intraspecific variability, temporal changes in an evolving lineage, sexual dimorphism or taxonomic diversity. With postcranial elements, this variability may indicate functional diversity.
- Two first metatarsals (Mt1) from Sterkfontein (StW 595 and StW 562) differ in their external shape[4], and here we report further analysis of the external morphology using geometric morphometrics and their internal trabecular and cortical structure.

AIM: Explore external and internal morphology of StW 595 and StW 562 Mt1s

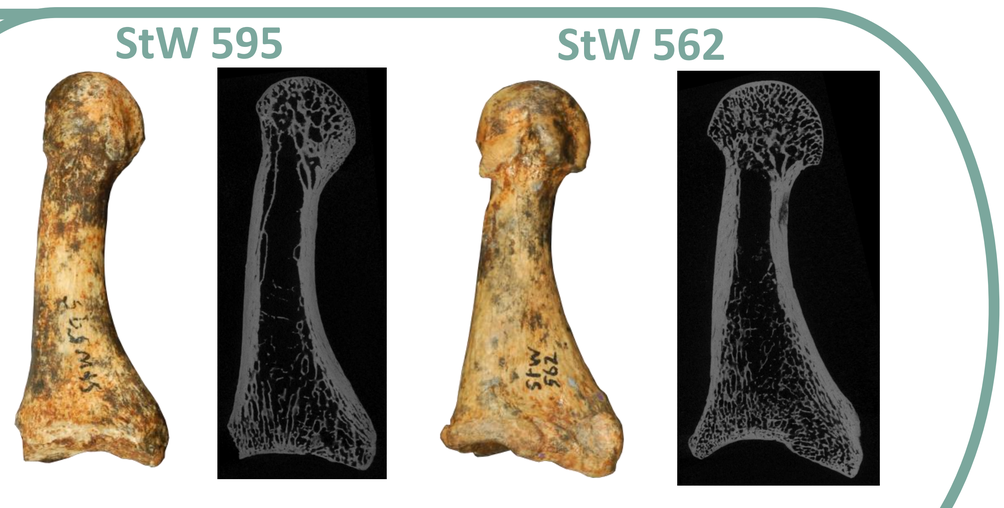

Figure 1. StW 595 and StW 562 first metatarsals, including images from micro-CT scans showing internal preservation

External Shape – GM Analysis

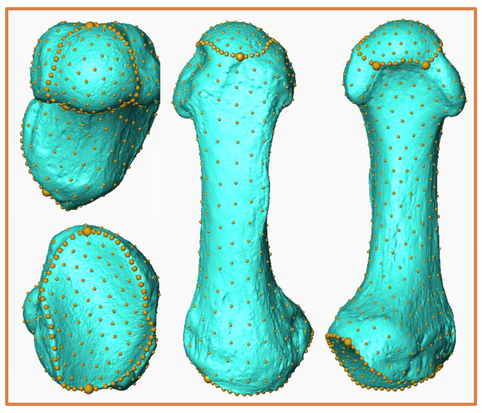

Figure 2. Landmark set showing both fixed and sliding curve and surface semi-landmarks

- The three fossils StW 562, StW 595 and SKX 5017 (*P. robustus*) are intermediate between the extant apes and humans
- Negative PC1 scores are associated with:
  - dorsoplantarly tall and flat proximal articular surface
  - low Mt1 shaft curvature
  - dorsally domed and mediolaterally expanded Mt1 head.

- The GM analysis **supports previous descriptions of the differing morphology of StW 595 and StW 562**[4], offering a quantitative comparison of the morphology of the entire metatarsal.

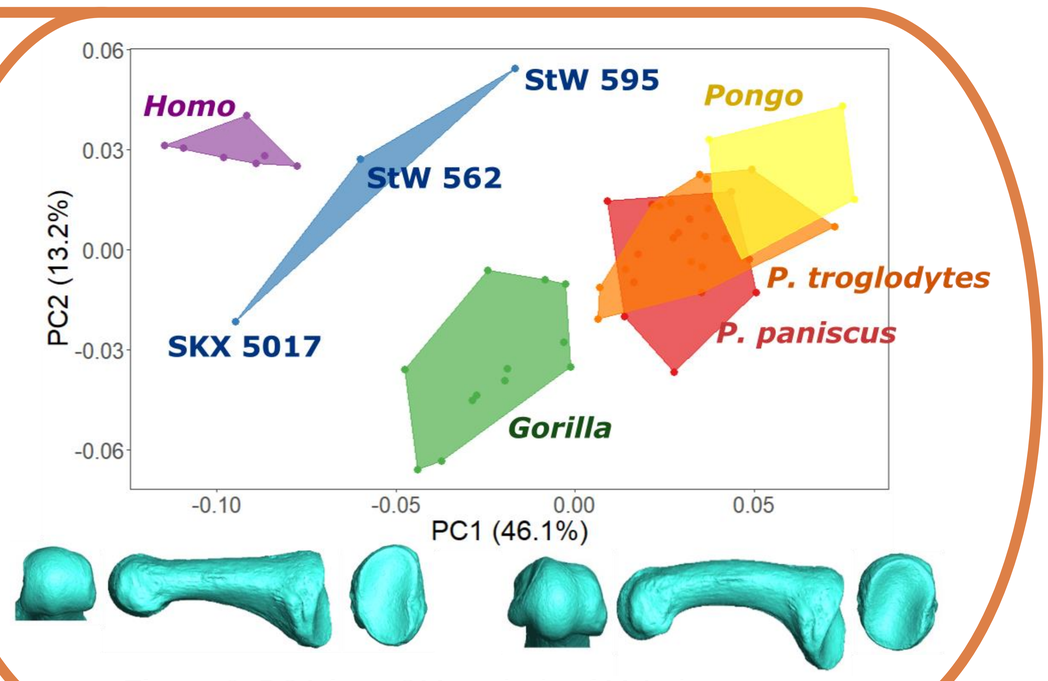

Figure 3. PCA from GM analysis of Mt1 shape

Midshaft Cross Sectional Geometry

- CSG analysis at mid-shaft demonstrates that the StW 595 metatarsal is more gracile than StW 562 and SKX 5017, **with StW 595 being most similar to *Pongo*** in both J and relative CSA
- The StW 562 and SKX 5017 Mt1s are similar in both J and CSA/length, being most similar to *Pan* and *Homo.*

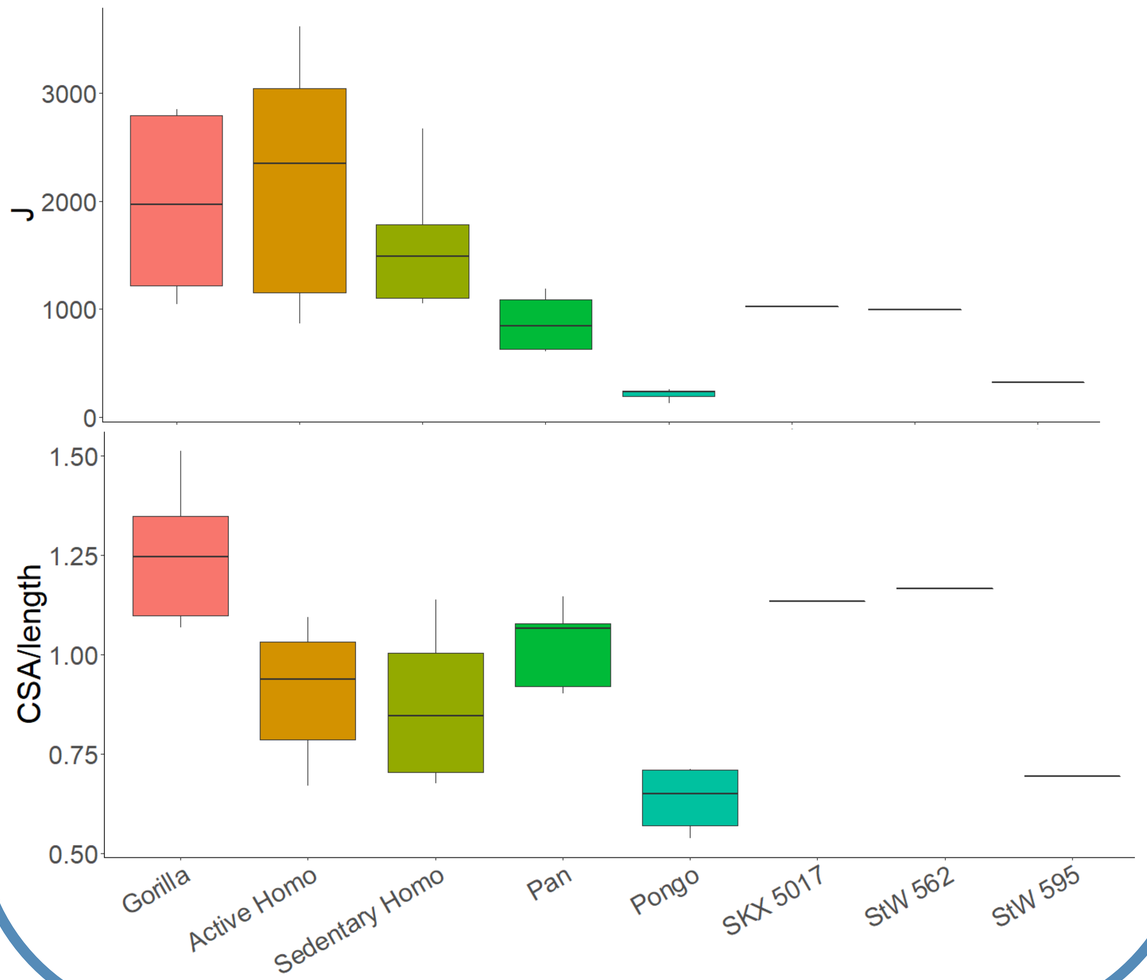

Figure 4. Results of CSG analysis at midshaft

Internal Morphology – Whole-Bone Analysis

- The distribution of the internal trabecular bone and cortical thickness of the Mt1 reflects the degree of first **metatarsophalangeal dorsiflexion** in extant apes and humans and other aspects of function[6,7].
- **StW 595:** despite its lacking dorsal doming of the metatarsal head, there is a concentration of bone dorsally suggesting a high degree of dorsiflexion. **StW 562:** although the head of StW 562 is dorsally domed, the highest concentration of bone is not as dorsally placed as SKX 5017 or SK 1813 (*P. robustus*/*Homo* sp.).
- The StW 595 and StW 562 fossils differ in the distribution of cortical bone.

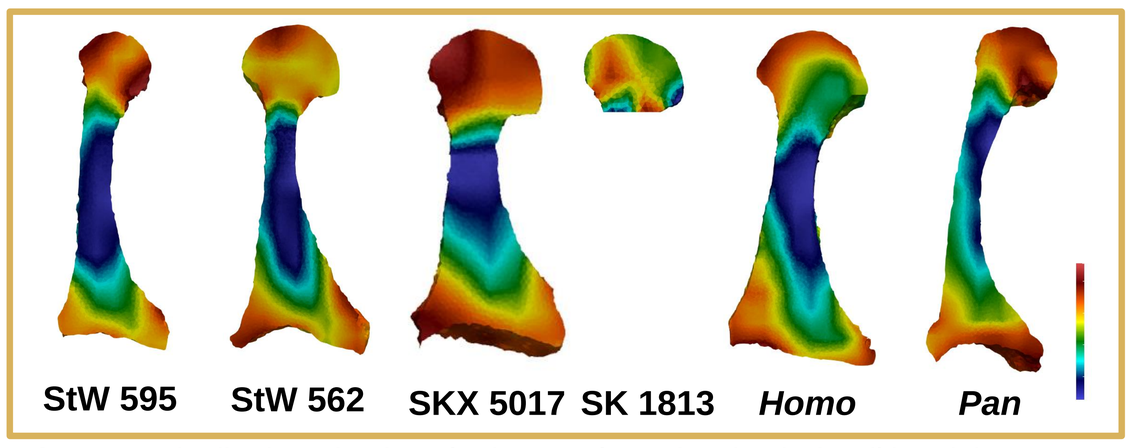

Figure 5. Distribution of trabecular bone volume fraction in fossil hominins, *Homo* and *Pan*, scaled to data range of each individual (some images from [5])

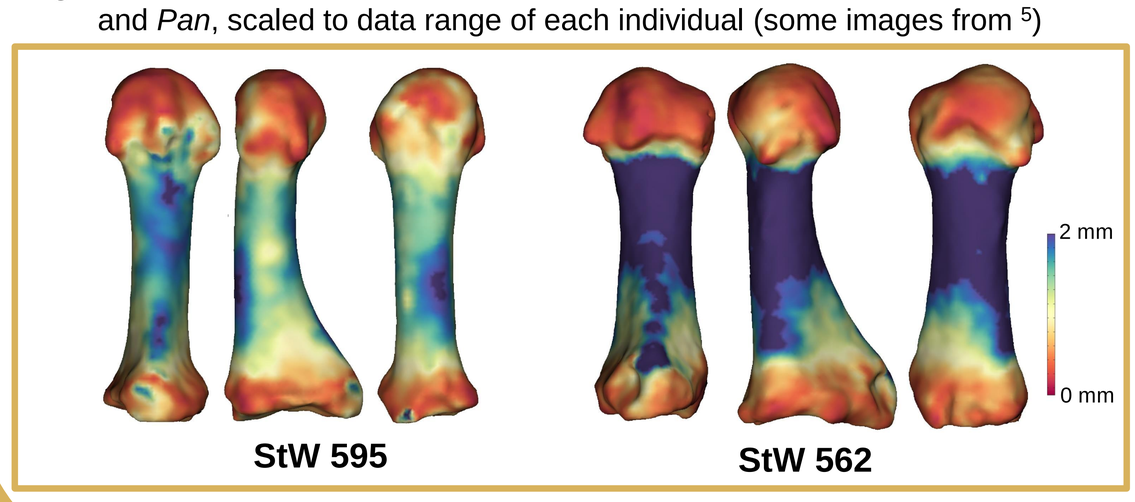

Figure 6. Distribution of cortical thickness in the StW 595 and StW 562 Mt1s, scaled from 0-2mm

Conclusions

- StW 595 and StW 562 differ in aspects of their external shape and internal cortical and trabecular bone structure.
- Results suggest **functional and/or taxonomic diversity may be present in the postcranial specimens from Sterkfontein MB4**, supporting previous research[1-5].

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