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Trabecular bone microarchitecture of the radial and femoral distal metaphyses during the period of locomotor behavior development.

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INTRODUCTION

- Trabecular bone microarchitecture (TBMA) adapts to variations in loading experienced during locomotion [1].
- TBMA is particularly useful in the study of **primate locomotor behavior** [2], but structural changes related to the development of human locomotion are not fully understood.
- The **crawling phase** of human ontogeny is an important step before bipedal walking in children [3], which leads to biomechanical modification on the **wrist and knee** for a relatively short period of time.

This study aims to characterize changes in TBMA in upper and lower limbs in a sample of juvenile humans.

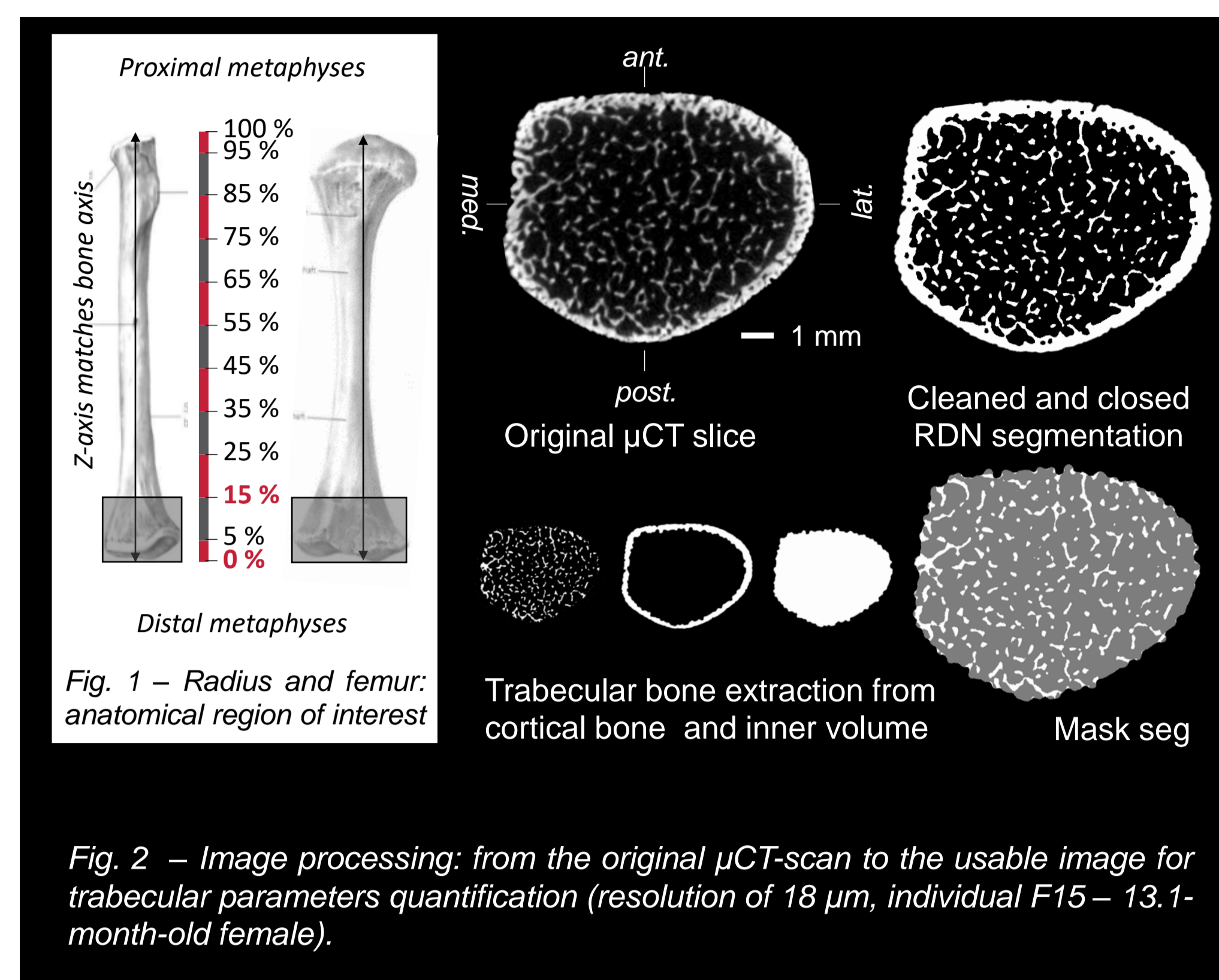


Fig. 2 – Image processing: from the original μ CT-scan to the usable image for trabecular parameters quantification (resolution of 18 μ m, individual F15 – 13.1-month-old female).

MATERIAL & METHODS

SAMPLE

- 26 children, [0-38] months old, from the Certosa identified skeletons collection, Univ. Bologna [4]
- Distal radial and femoral metaphysis** (Fig. 1) *without bone pathological signs* (20 radii, 25 femurs).

μ CT-SCANS

- Resolution of **9 or 18 μ m** (bone size dependent)
- SkyScan Brüker 1276 - acquisition protocol
- filter: 0.5 AI, source voltage: 70 kV, source current: 141 μ A, exposure time: 495 ms, rotation step: 0.5°, 360°
- Rotation mode, frame averaging: 3.

ANALYSIS PROTOCOL

- RDN segmentation** [5]
- Medtool 4.4** image processing (Fig. 2) & parameters quantified [6, 7]: bone volume fraction (BV/TV), degree of anisotropy (DA) and trabecular thickness (Tb.Th).

RESULTS

- Variation in TBMA parameters was observed **for both radial** (BV/TV) and **femoral** (BV/TV, DA, Tb.Th) metaphyses (Fig. 3).
- With advancing age**, the **radius** at first showed a **homogenous** distribution of BV/TV (Fig. 4 – M39, F22); then, a more **concentric pattern** with higher values medially (Fig. 4 – M12); and finally, a postero-medial **gradient of moderate values**.
- Simultaneously in the **femur**:
 - Tb.Th and BV/TV showed **no real differences** between medial and lateral sides (Fig. 4 – M39) and the TBMA was more isotropic at the periphery (Fig. 4 – M39).
 - Then, BV/TV, Tb.Th and DA showed **differences** between lateral and medial sides (Fig. 4 – F22, M12).
 - Finally, lateral and medial sides presented **high and similar** BV/TV and Tb.Th, and the bone is more isotropic at the midline (Fig. 4 – M12).

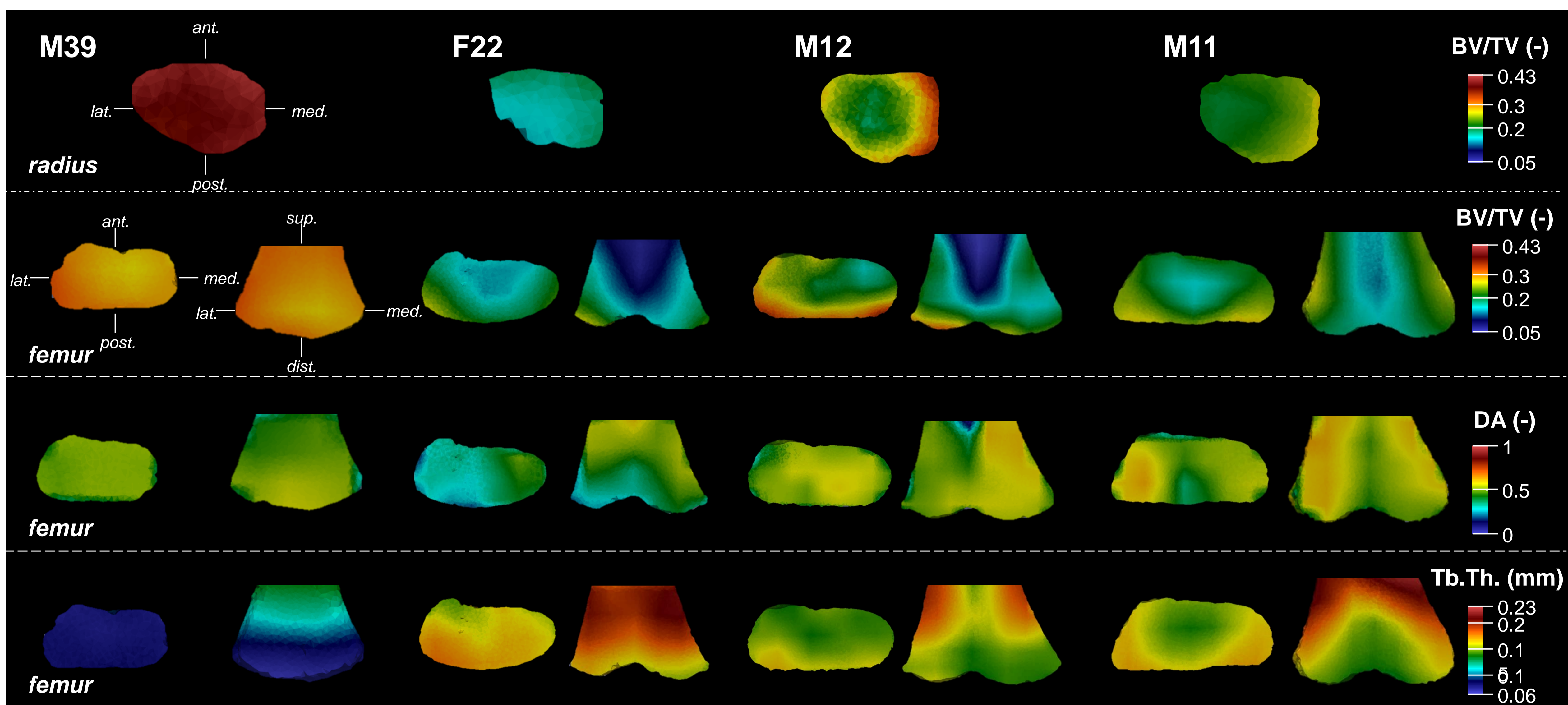
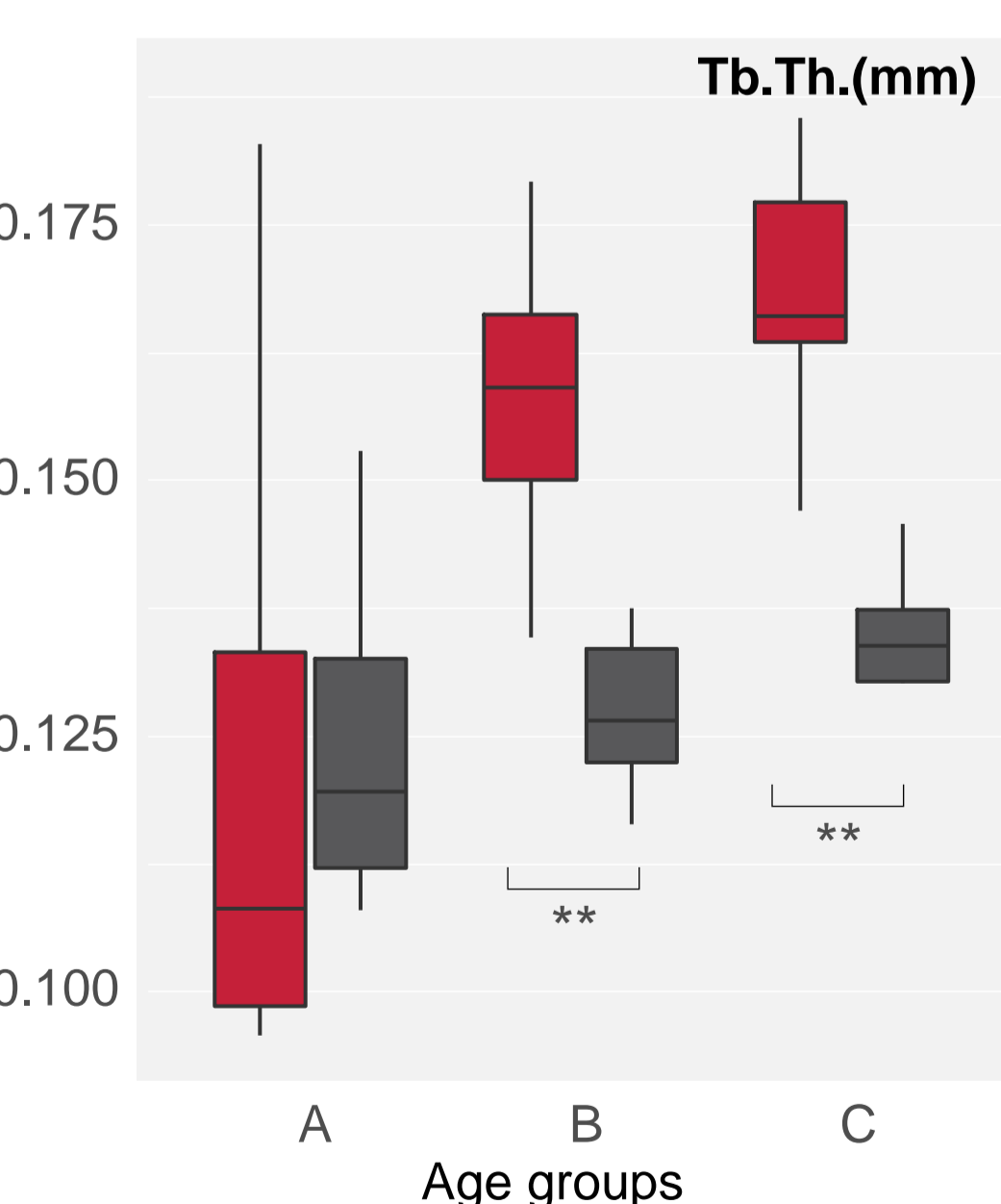
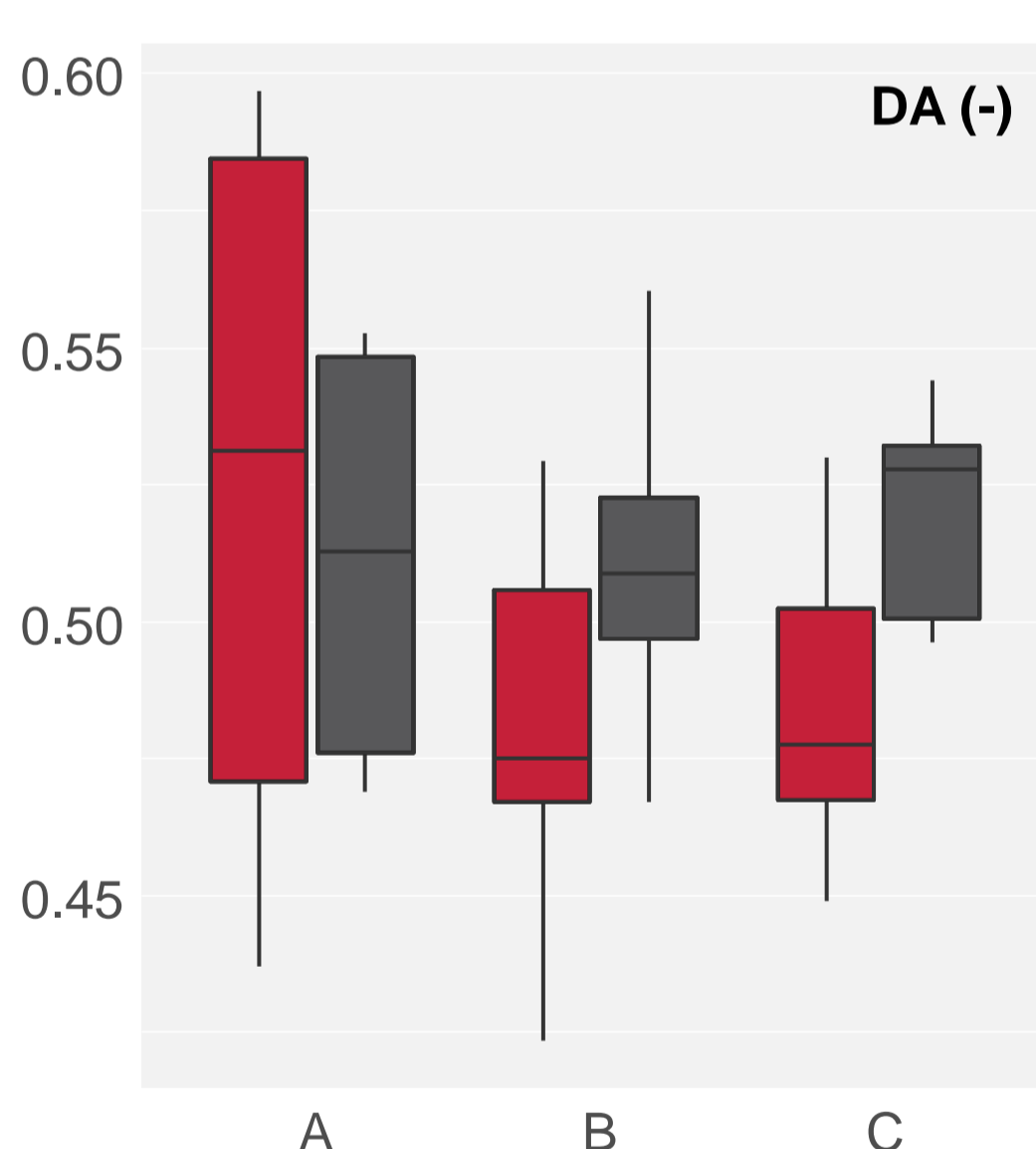
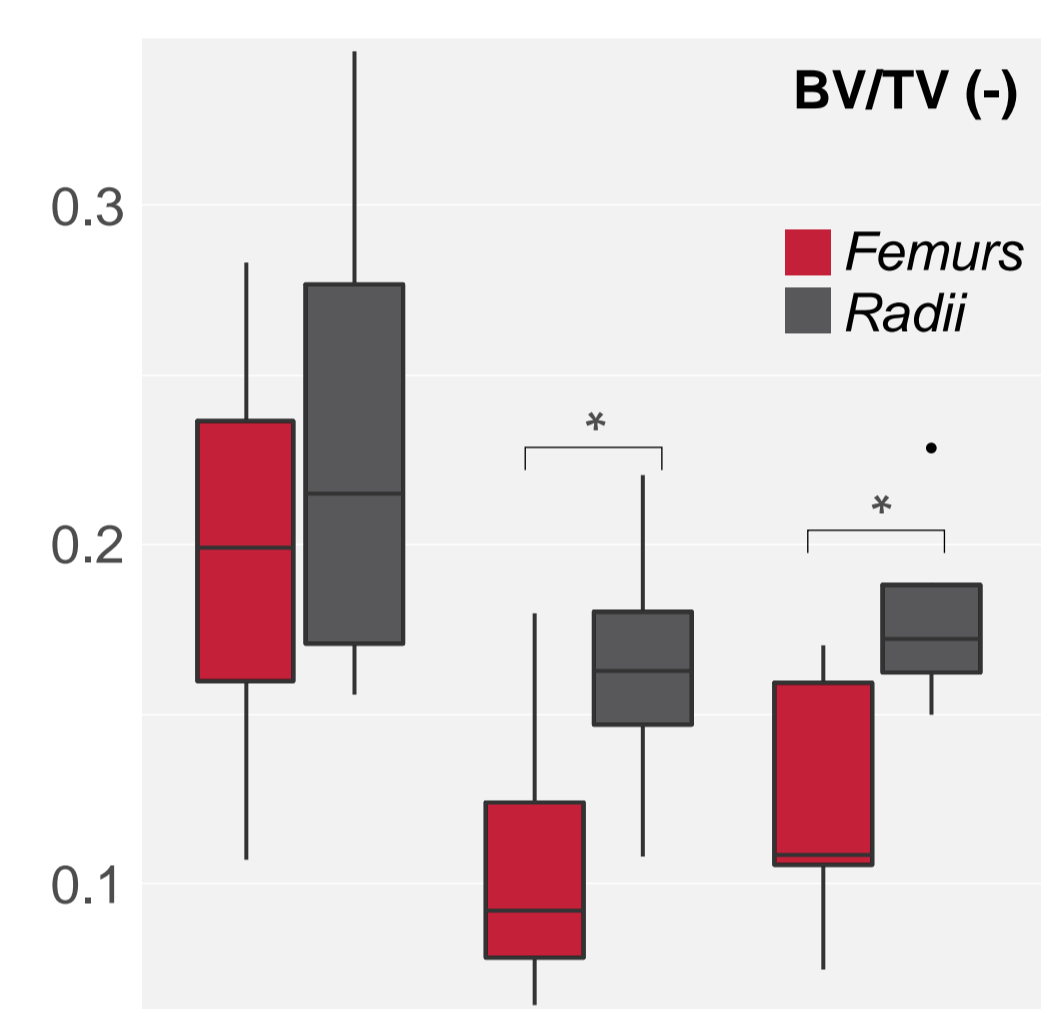


Fig. 3 (left) – Comparison of the quantified microarchitectural parameters per age group (A: [0-9], B: [9-18], C: ≥ 18 months old) between radius and femur metaphysis samples (Wilcoxon non-parametric test: * $p < 0.05$, ** $p < 0.01$).

Fig. 4 (top) – BV/TV, DA and Tb.Th. 3D maps of the distal radius and femur metaphyses, one individual for each age group (M39, 0-month-old male, for group A, illustrates very well TBMA organization at birth; F22, 9-month-old female for the first half of group B; M12, 15.5-month-old male for the second half of group B; M11, 23.5-month-old male for group C).

DISCUSSION & CONCLUSION

- These **patterns** of TBMA variation may relate to the acquisition and maturation of bipedal walking and the associated changes in loading as children transition through stages including pre-locomotion, crawling, and bipedalism.

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