Simulating hip growth in early humans

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Introduction

Importance of ilium in bipedalism

The human pelvis is uniquely adapted for bipedal walking, and the shape of the ilium plays an important role in locomotion.

Shape changes to the human ilium during growth and development reflect biomechanical adaptations.

Australopithecus africanus from South Africa walked bipedally around 3 million years ago, but their ilia have some shape attributes similar to both humans and non-human apes.

Ilium growth and development

Understanding the growth patterns of early human ancestors can aid in determining how those ancestors were using their bodies.

Hypothesis - *Australopithecus africanus* follows the same pattern of iliac growth as humans.

Methodology

Dataset

We established a dataset of 40 individuals in various stages of development from infancy to adulthood. We performed the same process on fossil *Australopithecus* ilia.

Landmarking

Viewbox 4 was used to collect 148 3D landmark coordinates for each individual.

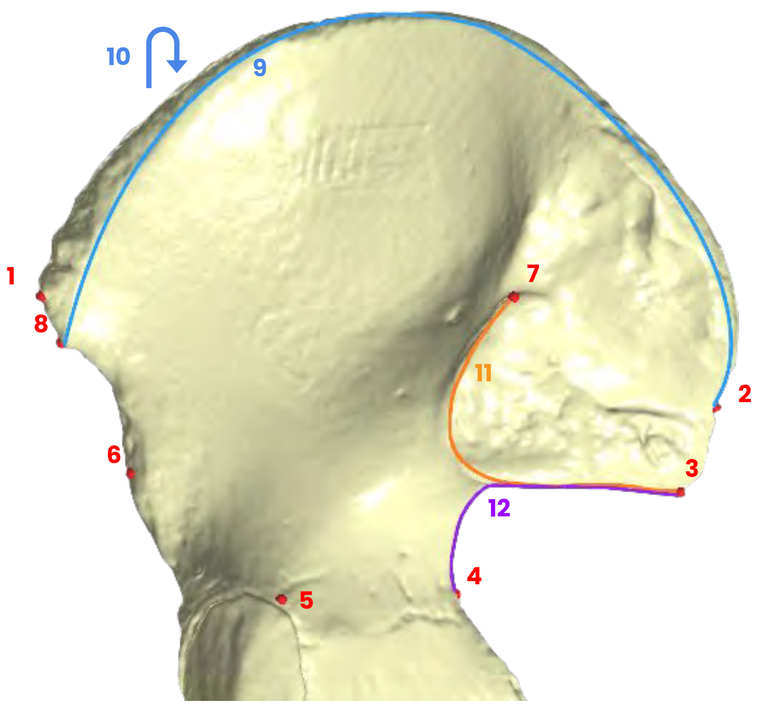

Fig 1. Landmark configuration. Fixed (Red): 1 ASIS, 2 PSIS, 3 PIIS, 4 Illioishium, 5 Illiopubis, 6 AIIS, 7 Auricular, 8 Anterior crest. Curves (Blue): 9 Medial Crest, 10 Lateral Crest (reverse side). Curve (Orange): 11 Auricular. Curve (Purple): 12 Sciatic Notch.

Results

We obtained a 3D growth trajectory with a principal component analysis (PCA), characterizing shape differences among human ilia that were caused by growth.

Using a linear regression model based on the PCA, we were able to “grow” ilia into later stages. Using this growth trajectory, we “grew” stage 3 fossils into stage 5, creating simulated adults compare to the fossil adult *Australopithecus* ilia STS 14.

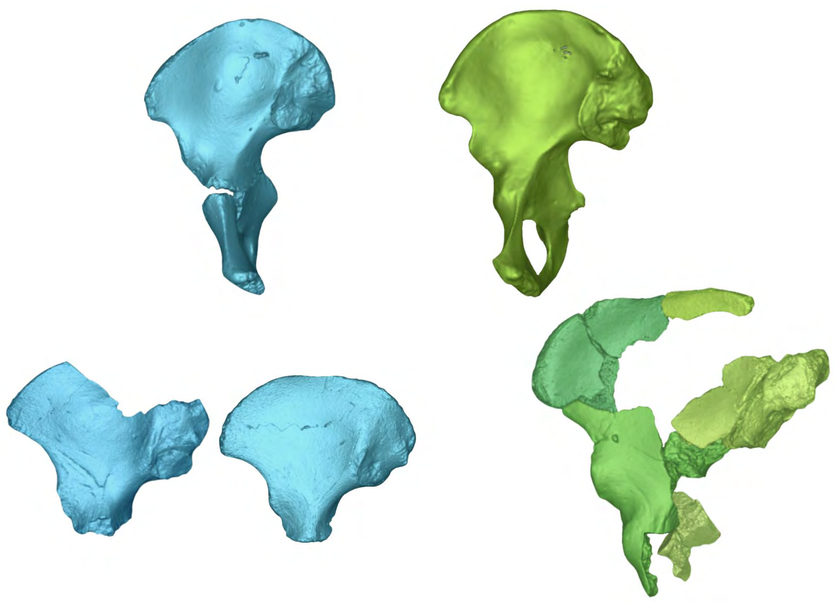

Fig 2. Comparison of human and fossil ilia. Top: Human ilia stage 3 (blue) and stage 5 (green). Bottom: *Australopithecus africanus* stage 3 ilia (MLD 25 and MLD 7) and stage 5 reconstructed ilia (STS 14).

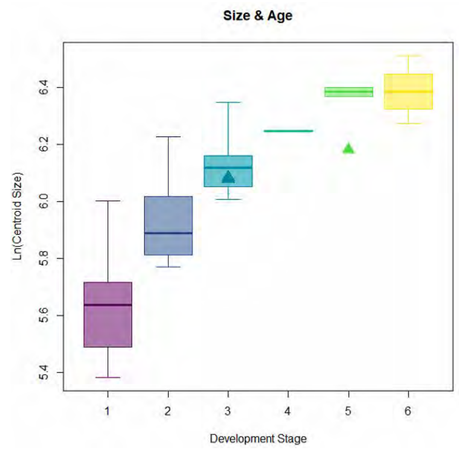

Fig 3. Ilium Size and Age. As age increases into adulthood, so does size. Triangles represent the 3 fossils (MLD 7, MLD 25, and adult STS 14) in the dataset.

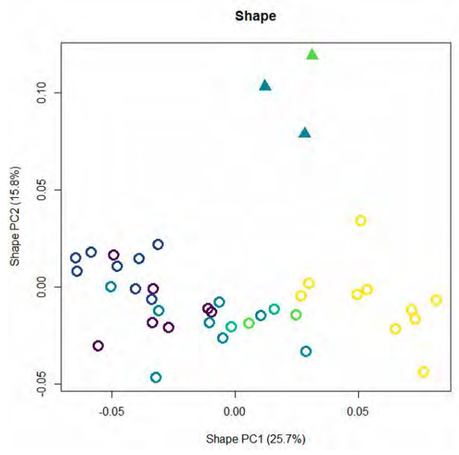

Fig 4. Ilium Shape. PC1 correlates with both size (geometric mean) and stage, and so represents growth. Notice the difference between the humans (circles) and the fossils (triangles).

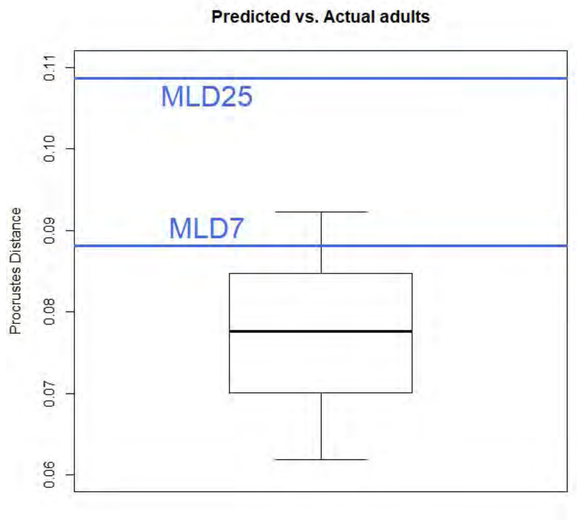

Fig 5. Procrustes distances (shape difference) between stage 3 human ilia “grown” to Stage 5 and the average stage 5 human ilia configuration. The blue lines represent Procrustes distances between Stage 3 Australopithecus ilia “grown” to stage 5 and the actual stage 5 Australopithecus STS 14.

Conclusions

MLD 7 grown into an adult fell within the human models’ margin of error, suggesting that it may have the same pattern of iliac growth as humans. The grown MLD 25 did not, and had a larger shape difference than any of the human ilia. This could be due to:

- Different growth patterns between species
- STS 14 may not be a good representative of the species

Future Directions

- Add more fossils to the dataset (STW 431)
- Apply method to more questions

References

Berge, C., (1998) *Heterochronic Processes in Human Evolution: An Ontogenetic Analysis of the Hominid Pelvis.* American Journal of Physical Anthropology.

Gunz, P. et al., (2012, February) *A uniquely modern human pattern of endocranial development. Insights from a new cranial reconstruction of the Neandertal newborn from Mezmaiskaya.* Journal of Human Evolution. https://doi.org/10.1016/j.jhevol.2011.11.013

McNulty, K. P. et al., (2006, April 2) *Examining affinities of the Taung child by developmental simulation.* Journal of Human Evolution.

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