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Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☐	☒ The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☒	☐ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐ The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐ A description of all covariates tested
☒	☐ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐ For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐ Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	Pelvic meshes were obtained from different authors (O. Lovejoy, D. Goularas P. Schmid and N.Laudicina provided their reconstructions of A.L. 288-1, Sts 14, and MH2, respectively). We then used Geomagic (www.3dsystems.com) to isolate the sacrum and Hypermesh 12.0 (www.altair.com) to generate new models with a simplified geometry.
Data analysis	The birth simulations were performed with finite-element analyses using the commercial software Radioss 11.0. Radioss is a solver of finite-element simulation that belong to the Hyperworks environment (www.altair.com)

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Here, we explore this obstetrical dilemma with dynamic finite-element birth simulations in Australopithecus using different fetal head sizes. We show that adaptation to bipedalism and the corresponding reshaping of the pelvis in these early hominins led to a tight fit between the mother's pelvis and the newborn head despite their relatively small brain sizes. To relieve this dilemma, australopithecines must have already given birth to secondarily altricial infants that were neurologically less developed than great apes. The evolution of a modern pattern of life history and cognitive development therefore seems to have predated the appearance of the genus Homo.
Research sample	We used 3 female australopithecine fossils preserve enough of the hipbones and sacrum to allow a reliable reconstruction of the pelvis, including A.L. 288-1 (Australopithecus afarensis), dated to 3.18 million years ago (Ma) (4 reconstructions), Sts 14 (A. africanus, 2.6-2.1 Ma) (2 reconstructions), and MH2 (A. sediba, 1.98 Ma) (1 reconstruction). All these specimens are of similarly small body size and they have birth canals of comparable cross-sectional area. Australopithecines are ideal for investigating the trade-off between n bipedal locomotion and encephalization as they have a bipedally adapted pelvis, yet relatively small brains. In combination with these pelvises, with used three fetal head model scaled to conform to the brain masses of 180 g, 145 g, and 110 g using the neurocranial dimensions of a chimpanzee neonate. This generates 21 virtual mother-infant dyads.
Sampling strategy	The sample size is constrained by the number of pelvic reconstructions: we considered all available published reconstructions of the three female australopithecine pelves
Data collection	The manual reconstruction of A.L. 288-1 and Sts 14 by Häusler & Schmid and the reconstruction of MH2 by Kibii et al. were scanned with a high-resolution surface scanner (PT-M4c, Polymetric GmbH, Darmstadt, Germany), while the other reconstructions were provided by the corresponding authors as digital models (Martin Haeusler, Cinzia Fornai, Nicole Webb). Our fetal skull model was based on a CT scan of a human fetus at 35 weeks of gestation. The CT scan was performed with a 16 slice Siemens SOMATOM Definition Flash strip scanner with 0.6 mm slice thickness. The CT images were segmented in Mimics 12.3 (www.materialise.com). The generated polygonal mesh of the fetal head was re-meshed in Hypermesh 12.0 (www.altair.com) to produce 18,000 shell elements with an average size of 1 mm (Pierre Frémondière, François Marchal, Lionel Thollon).
Timing and spatial scale	We obtained the model of A.L. 288-1 by Clark Owen Lovejoy the 24 May 2018. The original fossil is from Hadar, Ethiopie, discovered in 1974 We obtained the model of Sts-14 of Christine Berge the 4 June 2019. The original fossil is from Sterkfontein, South-africa, discovered in 1947 We obtained the model of MH2 by Natalie Laudicina the 16 October 2019. The original fossil is from Malapa, South-africa, discovered in 2008. The other reconstructions were already in our possession Gap between data acquisitions is explained by the multiple simulations we previously performed as initial steps of the research work. The fetal CT acquisition was performed the First october 2012 (1d-RCB 2011-A00072-39). Meshes were generate between April and december 2013, during the PhD thesis of Pierre Frémondière (http://www.theses.fr/2015AIXM5013)
Data exclusions	They were no exlusion criteria
Reproducibility	The models were checked against published measurements (inlet antero-posterior, inlet transverse, bispinous, biischiatic)
Randomization	Given the number of the pelvises considered (less than 10), we do not allocate pelvises into different groups
Blinding	Given the number of pelvises (less than 10) blinding was not relevant in our study

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☐	☒ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data
☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Palaeontology and Archaeology

Specimen provenance	A.L. 288-1 is from Hadar, Ethiopie, discovered in 1974. Sts-14 is from Sterkfontein, South-africa, discovered in 1947 MH2 is from Malapa, South-africa, discovered in 2008. No permits were obtained to work with these specimens
Specimen deposition	Surface scans were shared directly to Martin Haeusler by the different authors that performed the pelvic reconstruction
Dating methods	"no new dates are provided"

☒ Tick this box to confirm that the raw and calibrated dates are available in the paper or in Supplementary Information.

Ethics oversight	no ethical approval is required because our research did not involve human participation

Note that full information on the approval of the study protocol must also be provided in the manuscript.