Poster Presentation Number 16, Fr 19:00-19:45

Unravelling morphological changes of the human talus during growth

Carla Figus[1], Nicholas B. Stephens[2], Rita Sorrentino[3,1], Daniele Panetta [4], Maria Giovanna Belcastro [3,5], Timothy M. Ryan[2,6], Stefano Benazzi[1,7]

1 - Department of Cultural Heritage, University of Bologna · 2 - Department of Anthropology, Pennsylvania State University, University Park, PA · 3 - Department of Biological, Geological and Environmental Sciences - BiGeA, University of Bologna · 4 - CNR Institute of Clinical Physiology, National Research Council · 5 - ADES AMU-CNRS- EFS: Anthropology and Health, Aix-Marseille Université, F-13344 Marseille cedex 15, France · 6 - Center for Quantitative Imaging, Energy and Environmental Sustainability Laboratories, Institutes for Energy and the Environment, Pennsylvania State University, University Park, PA, USA · 7 - Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, Leipzig, Germany

The human talus, being located between the lower limb and foot, plays an essential role in distributing the weight of the body during locomotion. One of its most important functions during this process is in allowing for foot movements while efficiently dividing weight between its anterior and posterior portions, where it articulates with the navicular and calcaneus, respectively [1]. As such, the talus plays a pivotal role in the different stages of human locomotion, from crawling, to initial bipedal acquisition, to full striding bipedalism at age 8 [1]. Unfortunately, little is known about the morphological changes of the talus during the first years of life, when infants acquire upright posture and gait maturation. Using a (semi)landmark based approach we analyse an ontogenetic sample of modern human tali with the aim of exploring the morphological variation of the talus during growth. From this we assess if the variation may then be related to the acquisition and transition to full bipedal locomotion, which might ultimately provide insight into the evolution of hominin bipedalism. The sample consists of 21 juvenile tali aged between 1.5 years and 11 years: 12 individuals from the Collection of Bologna, Italy (sex and age at death known) [2]; five from the archaeological sample of Roccapelago (Italy) [3]; four from the archaeological sample of Norris Farms #36 (Illinois, USA). All specimens were microCT scanned with a resolution of 20-40 μm. Avizo 9.3® (Visualization Sciences Group, SAS) was used to evaluate the quality of and pre-process the reconstructed scan data (e.g. crop or resample). Segmentation of the image data was performed using the MIA-clustering method [4] and then processed in Medtool 4.2 (Dr. Pahr Ingenieurs.e.U) to obtain 3D meshes of each talus. A template of 11 landmarks, 61 curve semilandmarks and 144 surface semilandmarks was created in Viewbox (dHAL Software) and applied to the 21 tali. The (semi)landmark configuration was superimposed by Generalized Procrustes Analysis, and semilandmarks were allowed to slide against recursive updates of the Procrustes consensus [5]. Finally, a form space Principal Component Analysis was carried out to explore talar shape variation during growth. Data were processed in R 3.4.3 (The R Foundation for Statistical Computing, 2017). The first three PCs explain 92.9% of the total variation. Most of the morphometric variation is explained by PC1 (89.8%), i.e. ontogenetic allometry, where negative scores account for small, sub-parallelepiped talar morphology (the youngest individuals), while positive scores account for an elongation of the entire body of the talus, due to the development of the neck, and a clear growth of the lateral malleolar facet, while the posterior side of the trochlear facet is not well defined yet. The anterior calcaneal facet is well developed since the youngest phases (negative scores), while the posterior calcaneal facet becomes larger, less triangular, and more concave towards PC1 positive. PC2 (1.7%) and PC3 (1.4%) describe only subtle morphological differences. Negative values of PC2 account for a longer lateral ridge, that shortens along positive values, due to the growth of the talar head, development of the neck, trochlea, and lateral malleolar facet, with a more concave aspect of the lateral side. It is also possible to discern a narrowing of the sulcus tali and a clear medial rotation of the talar head. PC3 negative scores show a more compact shape, that becomes higher along positive values with the development of the posterior calcaneal facet and head. This study is part of an ongoing project focusing on ontogenetic changes. Here we present preliminary results showing how external talar morphology varies during the early stages of human bipedalism. Future analyses will combine external morphological analyses with an assessment of trabecular bone architecture, thus providing a more holistic vision of these changes during development.

This project is funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 724046 - SUCCESS); website: http://www.erc-success.eu/. We are grateful to Dr Mirko Traversari for his willingness on the use of the Roccapelago sample.

References:[1] Hellier, C.A., & Jeffery, N. 2006. Morphological plasticity in the juvenile talus. Foot and Ankle surgery, 12(3), 139-147.[2] Belcastro, M.G., Bonfiglioli, B., Pedrosi, M.E., Zuppello, M., Tanganelli, V., & Mariotti, V. 2017. The history and composition of the identified human skeletal collection of the Certosa Cemetery (Bologna, Italy, 19th20th century). International Journal of Osteoarchaeology. DOI: 10.1002/oa.2605[3] Figus, C., Traversari M., Scalise L. M., Oxilia G., Vazzana A., Buti L., Sorrentino R., Gruppioni G., Benazzi, S. 2017. The study of commingled non-adult human remains: Insights from the 16th-18th centuries community of Roccapelago (Italy). Journal of Archaeological Science: Reports, 14:382-391[4] Dunmore C.J., Wollny G., Skinner M.M. (2018) MIA-Clustering: a novel method for segmentation of paleontological material. PeerJ 6:e4374[5] Rohlf, F.J., Slice, D. 1990. Extensions of the Procrustes method for the optimal superimposition of landmarks. Syst. Biol. 39, 40-59.