Poster Presentation Number 79, Session 3, Friday 2:00-3:00 pm

Measuring the asymmetry in long bone morphometric maps of cortical thickness: occupation-related differences in the modern human humerus

Carlotta Zeppilli[1], Antonio Profico[2], Ileana Micarelli[1], Damiano Marchi[3], Paul O'Higgins[2,4], Giorgio Manzi[1]

1 - Department of Environmental Biology, Sapienza University of Rome (Italy) · 2 - PalaeoHub, Department of Archaeology, University of York (UK) · 3 - Department of Biology, University of Pisa (Italy) · 4 - Hull York Medical School, University of York (UK)

Reconstructing the loading history in human species is crucial to understand lifestyle strategies and mobility pattern in past populations. A fundamental approach to the reconstruction of physical behaviour relies on the comparison of the differences in cortical thickness distributions among antimeres. The comparison of antimeric bones from the same individual offers the prospect of identifying asymmetry of loading and so, of activity, because genetic, systemic and environmental factors affecting bone form are the same for both sides [1]. In the present study we have tested the new *morphomapAsymmetry* function, an implementation of *morphomap* R package [2], to calculate and map asymmetry of the cortical thickness. We selected 41 male individuals and 10 female individuals from *The New Mexico Decedent Image Database* (NMDID) [3]. We chose only individuals ranging in age from 20 to 50 who have worked in the army, in building companies or at a desk. We tested the hypothesis that diaphyseal cortical thickness asymmetry is unrelated to occupation and sex. On each humerus we extracted 61 cross-sections along the diaphysis from 20% to 80% of the total biomechanical length. On each cross-section we calculated 48 equiangular semilandmarks: 24 on the periosteal and 24 on the endosteal contour, centred at the centre of gravity of the cross-section. The right humeri have been mirrored by using the function *morphomapMirror*. We measured the thickness between paired semilandmarks (periosteal and endosteal), and we built morphometric maps of cortical thickness for each individual. Eventually, we computed the difference between right and left sides and mapped the differences in morphometric maps. In this way, the diaphysis is unrolled and the differences in thickness along the direction (anterior-lateral-medial-posterior) and the longitudinal axis are reported respectively on the x and y axis. We analysed asymmetry by performing a principal component analysis on the matrices of cortical thickness of the left and right humerus. Each individual is represented by left and right morphometric maps of cortical thickness after subtracting the mean morphometric maps between sides. We calculated the pattern and magnitude of asymmetry pooled by occupation and sex. Additionally, we decomposed the total asymmetry into the "directional" and "fluctuant" components of asymmetry [4,5]. The first two PC scores account for the 33.91% of the total variance (PC1=41.05%; PC2=7.47%). PC1 is related to directional asymmetry showing a shared pattern of right-hand lateralization (except one individual left-hand lateralized). The pattern and magnitude of asymmetry among the three occupation groups are not statistically different from each other. However, the magnitude of total asymmetry is higher in army and building than desk group. The decomposition of the asymmetry into directional and fluctuant components reveals as 9.60% of the total variance is associated with directional asymmetry and 90.4% with fluctuant asymmetry. Lastly, the comparison between female and male individuals show as the pattern of asymmetry is indistinguishable. On the contrary, the magnitude of asymmetry is higher in the male subsample. The analysis of asymmetry of the cortical thickness presented here confirmed a general trend of right lateralization among the individuals belonging to the different groups of occupation. Males show a higher degree of asymmetry than females. In conclusion, these results do not falsify the hypothesis that pattern and magnitude of asymmetry differ among the occupation groups considered in this study. In perspective, recent developments in statistical analysis methods applied to the study of skeletal material show the potentiality of this approach to study the pattern of lateralization in relation to physical activity in past populations including extinct human species.

We thank the New Mexico Decedent Image Database for providing the 3D models of modern human humeri. This project has received funding from the European Union's Horizon 2020 research and innovation programme (H2020 Marie Skłodowska-Curie Actions) under grant agreement H2020-MSCA-IF-2018 No. 835571 to Antonio Profico and Paul O'Higgins.

References: [1] Ruff, C., Jones, H., 1981. Bilateral asymmetry in cortical bone of the humerus and tibia—sex and age factors. Human Biology, 53(1), 69-86. [2] Profico. A., Bondioli, L., Raia, P. et al., 2020. morphomap: an R package for long bone landmarking, cortical thickness and cross-sectional geometry mapping. AJPA. [3] Edgar, HJH., Daneshvari Berry, S., Moes, E. et al., 2020. New Mexico Decedent Image Database. Office of the Medical Investigator, University of New Mexico. [4] Mardia, K. V., Bookstein, F. L., & Moreton, I. J., 2000. Statistical assessment of bilateral symmetry of shapes. Biometrika, 285-300. [5] Neubauer, S., Gunz, P., Scott, N. A., et al., 2020. Evolution of brain lateralization: A shared hominid pattern of endocranial asymmetry is much more variable in humans than in great apes. Science advances, 6(7), eaax9935.