The ontogeny of bipedalism: insights from trabecular changes during growth

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INTRODUCTION

The evolutionary history of bipedalism is a point of enthusiastic debate in paleoanthropology. During development, cultural influences and other factors (e.g. stance, step length, and pace) are known to affect the acquisition of bipedal locomotion [1]. While there is evidence for a bone functional adaption in relation to gait maturation of the femur, in the form of trabecular architectural (re)modelling[2], very little is known about trabecular architectural changes in the human foot during the transition from crawling to walking.

MATERIALS AND METHODS

μCT scans (20–40 μm) of 28 juvenile tali (modern known age = 16; archaeologically estimated age = 10) were grouped into 5 age classes. Segmentation into bone and air was performed using the MIA-clustering algorithm [3]; trabecular bone isolation and quantification was performed in Medtool 4.2 [4]: Bone volume fraction (BV/TV), degree of anisotropy (DA), elastic modulus (E), thickness (Tb.Th), spacing (Tb.Sp), total surface (Tb.TS), and total volume (Tb.TV).

RESULTS

Significant results (p<0.05) between age classes were found for E (8wk-1 and 1.1-3 years), and Tb.TS (3.1-6, 6-10, and 10.1-15 years). Among the age classes Tb.Th, Tb.Sp, and Tb.TV steadily increase with age. BV/TV and E were lowest for individuals in the second oldest class (14%, 6.7), and highest in the oldest class (17.9%, 10.8). DA is relatively isotropic in the youngest class (.16), becoming more anisotropic and plateaing in older classes (.22-.23).

DISCUSSION AND CONCLUSIONS

The increase in architectural variables relative to age, is expected. BV/TV and E are at their lowest in the age class (1.1-3 years), which coincides with the developmental period when modern children begin walking unassisted. These preliminary results agree with a similar study on the radius [5]. Future analyses will include the external morphology and cortical bone thickness that will provide a more complete picture of talar development in humans. Following this, these results may then be extended to studies of non-human primates and fossil taxa, which could then ultimately be useful in identifying developmental milestones related to the evolutionary history of committed terrestrial bipedalism.

REFERENCES


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