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Morphological Changes in Foot Phalanges and the Development of Quadrupedalism in Ornithopods: A Biomechanical Approach

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In the evolution of the ornithopods from theropods, there was a change of posture from bipedalism to facultative quadrupedalism and a consequent forward shift in the center of mass. The foot bone morphology was modified accordingly: a basal digitigrade foot posture evolved to a more unguligrade posture; unguals evolved from claw to hoof; and pedal phalanges that were longer than wider became the more derived flattened condition seen in hadrosaurids. Despite these differences, the footprints of theropods and ornithopods are easily confused because they share the same phalangeal formula. Many studies have attempted to distinguish between the two types of footprints, but preservational biases can hinder the ability to recognize features like the presence of sharp claw marks or slight differences in the length to width ratio. The only clear indicator is the presence of manus prints in the case of ornithopods. However, recent research of foot bone morphology suggests that there is a difference in kinematics and distribution of forces along the pes between the two orders. This information is necessary to understand the biomechanics of dinosaur feet and may be useful for footprint identification.

To constrain the foot biomechanics it is important to look at the trabecular structure, which reveals the principal stresses undergone by the bone. Three-dimensional images of phalanges obtained by CT and laser scanning were used to 1) study trabeculae architecture and 2) to create a model to predict the principal stress distribution in a wide variety of phalangeal morphologies. With the application of this method it is possible to correlate the phalangeal morphological changes with the forward shift in the center of mass throughout ornithopod evolution and to compare between theropod and ornithopod foot biomechanics.