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Elbow Motion in Walking Alligators

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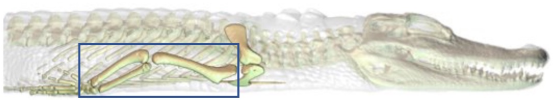
Introduction:

Crocodylia regularly use a "high-walk" during terrestrial locomotion unlike other non-mammals, thus drawing interest from both biomechanical and evolutionary research communities. Here, we employ the highly accurate XROMM (X-ray Reconstruction of Moving Morphology) method to measure joint motion between the three forelimb bones (humerus, ulna, and radius) of alligators performing high-walks on a treadmill. This method literally “re-animates” bone motion by combining bi-planar X-ray video with digital bone models from CT scans in the animation program Maya (Autodesk).



Anatomical Model:

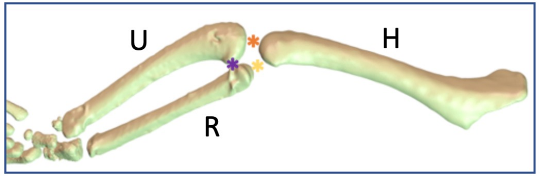


Figure 1. Alligator elbow joint. The elbow consists of articulations between three bones forming the humero-ulnar joint, humero-radial joint, and radio-ulnar joint. In this study, we limit our focus to the humero-ulnar joint. H = humerus, U = ulna, R = radius.

Hypothesis:

We predict that there will be a larger range of motion for flexion/extension in both the humero-ulnar and humero-radial joint, while the radio-ulnar joint will show a significantly smaller range. We also predict that the radio-ulnar joint will show a larger range of motion for long-axis rotation than the other two joints. For range of translation, we predict that none of the three joints will show a significant range of motion.

Methods:

We used XROMM (Brainerd et al. 2010, Knorlein et al, 2016) “re-animate” 3D skeletal motion by combining in vivo x-ray videos with Computed Tomography (CT Scans). We calculated relative joint motion for the humero-radial, humero-ulnar, and radio-ulnar joints, then scaled the animation into half-strides to compare ranges of joint motion for 3 rotational and 3 translational degrees of freedom.

Elbow Motion:

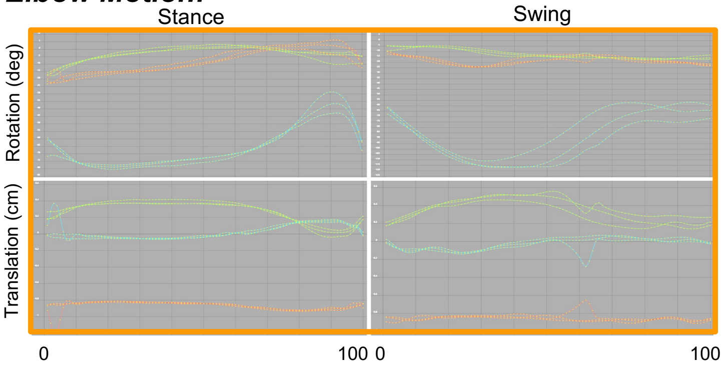


Figure 2. Humero-ulnar joint motion across three stances and three swing phases. Animation was scaled from 0-100 frames for each half stride.
Orange = long-axis rotation (x-axis), Green = Abduction/Adduction (y-axis), and Blue = Flexion/Extension (z-axis)

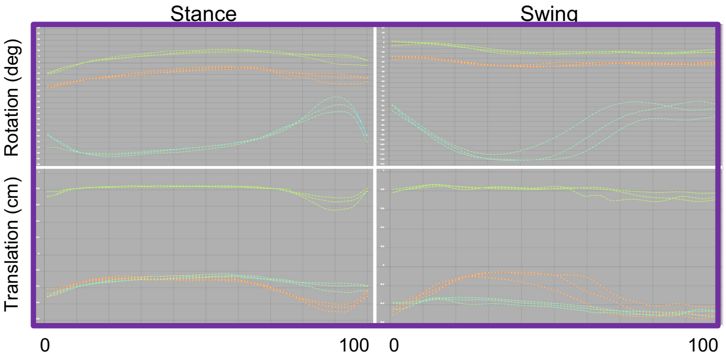


Figure 3. *Humero-radial joint motion across three stances and three swing phases. Animation was scaled from 0-100 frames for each half stride.*
Orange = long-axis rotation (x-axis), Green = Abduction/Adduction (y-axis) and Blue = Flexion/Extension (z-axis)

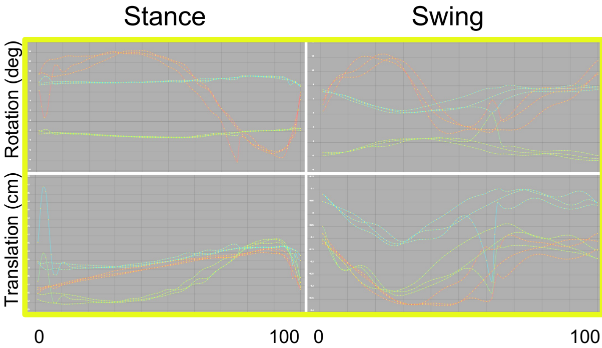


Figure 4. Radio-ulnar joint motion across three stances and three swing phases. Animation was scaled from 0-100 frames for each half stride.
Orange = long-axis rotation, (x-axis) Green = Abduction/Adduction (y-axis), and Blue = Flexion/Extension (z-axis)

Conclusions:

From the joint motion data graphed, we observed that the humero-ulnar and humero-radial joint showed a larger range of motion for flexion/extension, and a smaller range of motion for both long axis rotation and abduction/adduction. Range of translation is also small for both joints. We also expected the radio-ulnar joint to show a large range of motion for long-axis rotation and a smaller range of motion for flexion/extension and abduction/adduction, however we did not expect that there would be a large range of translation from the radio-ulnar joint.

Future Research:

In the future, it may be beneficial to look at multiple alligators to have a broader scope of the rotational degree measurements.

References:

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