A Full-Body Biomechanical Model and Novel Forelimb Muscle Forces in *Tyrannosaurus rex*

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INTRODUCTION

- Biomechanics allows us to infer the function and behavior of extinct taxa[1,2]
- Musculature in extinct taxa can be reconstructed through a combination of phylogenetic inference and fossil evidence[1,2,3,4]
- Previous analyses have created muscle models to estimate physiological cross-sectional area (PCSA) and calculate maximum contractile force[1,2]

$$PCSA = \frac{V \times \cos(\theta)}{L}$$

$$F_{max} = PCSA \times ST$$

- The forelimb musculature of *Tyrannosaurus rex* has never previously been modeled[3]
- No previous analyses have attempted to integrate different systems of muscles to model full-body movements

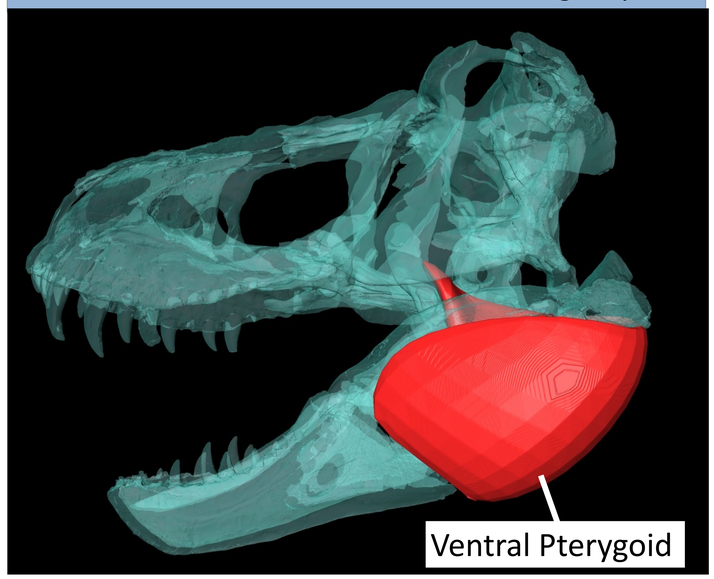
OBJECTIVES

- Estimate the maximum contractile force for each humeral protractor and retractor[4]
- Make functional and behavioral inferences based on our biomechanical model
- Create an atlas of *Tyrannosaurus* musculature for future research[7]

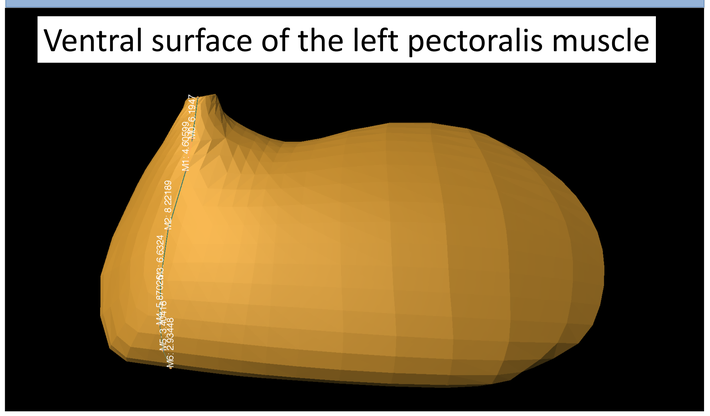
METHODS

Digital models of a *Tyrannosaurus rex* skeleton were constructed from photos with Agisoft Metashape[5]

Muscles based on extant taxa and previous literature were modeled around the skeleton using Maya[6]



Lengths and volumes of muscles were measured in Meshlab



Muscle length data was used to estimate maximum contractile forces for three different fiber lengths

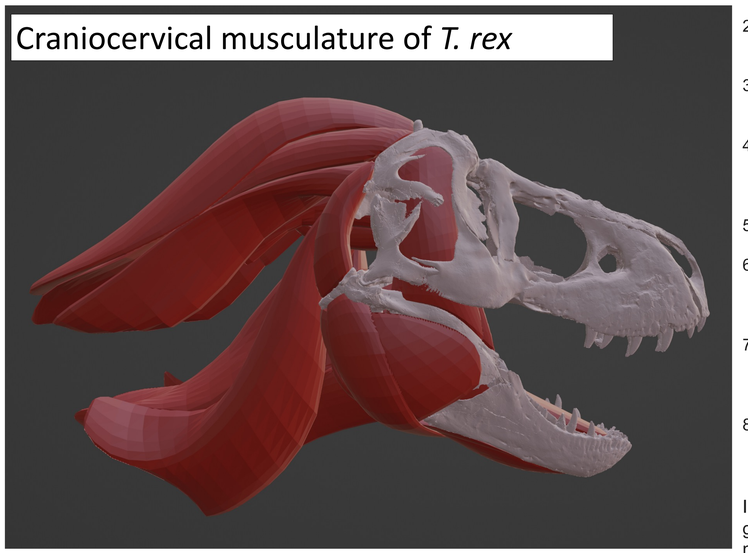
RESULTS

Novel Muscle Force Estimates – Humeral protractors[4] in green, humeral retractors in red

Muscle Name	Volume (cm^3)	Length (cm)	Maximum Contractile Force (N)
M. pectoralis	5,748.85	45.39	3,856-11,018
M. coracobrachialis brevis dorsalis	4,785.88	44.21	3,296-9,418
M. supracoracoideus brevis	1,304.19	31.54	1,259-3,597
M. supracoracoideus intermedius	876.72	28.42	939-2,683
M. latissimus dorsi	22,530.82	182.02	3,769-10,767
M. subscapularis	1,881.01	78.69	728-2,079
M. scapulohumeralis caudalis	1,102.68	40.92	820-2,344

DISCUSSION

- *Tyrannosaurus rex* was capable of powerful forelimb movements[3]
- Powerful forelimb musculature may be indicative of forelimb use during predation
- This model provides force estimates for previously unanalyzed muscles in *T. rex*
- Incorporating musculature from different regions of the body will allow us to model movements across those different regions



FUTURE DIRECTIONS

- Pair biomechanical data with trabecular orientation[8]
- Muscle moment arms and forces will quantify torque about joints[1]
- Comparisons between *Tyrannosaurus rex* and other taxa will better establish variation across Theropoda[1]

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