**Neuromechanics of Guinea Fowl Jumping: Role of distal muscles in take-off and landing**

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## Summary

Countermovement (CM) enhances jump performance by pre-stretching muscles and tendons, facilitating elastic energy storage and recoil [1]. While extensively studied in humans, the role of CM in avian jumping remains less clear. The crouched posture of birds raises questions about its necessity [2,3]. Guinea fowl (*Numida meleagris*), an athletic biped, provides a model to examine CM's role in avian jump performance [2]. This study investigates how CM variations influence muscle-tendon unit (MTU) function and jump performance, focusing on the contribution of distal hindlimb extensors to take-off and landing stabilization. We analyzed substrate forces, body center of mass (CoM) dynamics, and *in vivo* muscle mechanics to understand the integration across body motion, muscle-tendon dynamics, and jump performance [2,3]. This approach evaluates neuromechanical integration in dynamic environments, providing insight into how birds regulate jump mechanics to optimize performance and stability.

## Introduction

Birds' crouched posture may reduce the necessity of CM to increase range of motion [2]. This study examines CM variations in MTU function and CoM dynamics, particularly how distal muscles contribute to power transmission and stabilization. By assessing neuromechanical strategies, we aim to clarify how MTU dynamics integrate with whole-body movement to support jump performance.

## Methods

Guinea fowl were trained to jump onto perches under varying conditions. We captured kinematics via high-speed video (200 fps) and ground reaction forces via a force plate (1000 Hz) To assess their respective roles in jump initiation and landing stabilization, we surgically implanted the lateral gastrocnemius (LG) and digital flexor-III (DF-III) muscles with sonomicrometry to measure muscle strain, electromyography (EMG) to record activation patterns, and tendon force buckles to quantify force transmission.

## Results and Discussion

We hypothesize that the LG contributes significantly to both force and power generation for take-off, while the DF-III plays a critical role in developing high forces to facilitate power transfer between proximal and distal joints, without directly contributing substantial work for the jump. Due to its multi-articular structure, the DF-III facilitates efficient force transmission, rather than directly providing power and work. Also, the DF contributes to stability upon landing. Unstable perches may require greater DF-III activation to dampen oscillations and control balance [4], while higher perches increase force demands (Figure 1) [2].

By analyzing *in vivo* force-length dynamics alongside whole-body kinematics, we aim to explain how MTUs with different architectures contribute to neuromuscular control of jumping. Differences in joint flexion and muscle activation patterns upon landing may indicate compensatory strategies that accommodate variations in perch conditions.

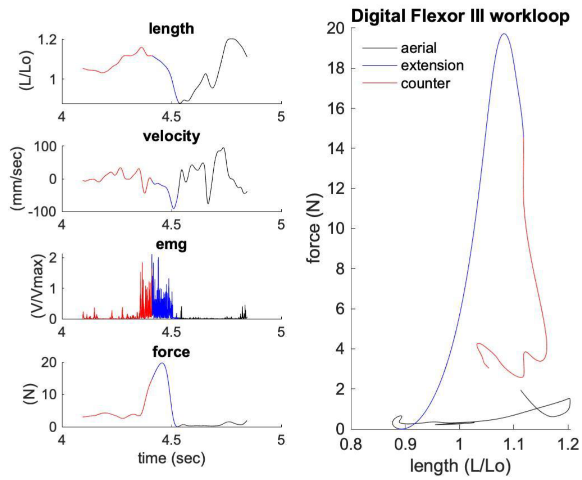


**Figure 1**: DF-III muscle mechanics during guinea fowl jumping. Lo indicates resting length. Color indicates different phases of the jump (red = countermovement, blue = extension of legs, black = aerial). Left: length, velocity, EMG, and force over time. Right: Work loop (force x length) of guinea fowl jumping.

## Conclusions

Findings indicate that countermovement mechanics strongly influence jump performance, with countermovement displacement correlating with kinetic energy (KE) ($r = 0.47$), take-off velocity ($r = 0.49$) and peak power ($r = 0.47$). A lower force minimum during CM correlates with higher jump KE ($r = -0.48$), peak power (-0.51), and take-off velocity ($r = -0.49$), suggesting variations in CM dynamics affect jump efficiency. Differences in muscle activation and length dynamics between the LG and DF-III will provide insights into the relationship between MTU morphology and task-dependent functional contributions. These findings enhance our understanding of bipedal locomotion, postural control in dynamic environments, and individual variation in response to environmental challenges [1-5].

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## References

[1] Roberts & Azizi. (2011). *JEB*, **214**: 353-361
[2] Henry et al. (2005). *JEB,* **208**: 3293-3302
[3] Daley & Biewener (2006). *PNAS*, **103**: 15681-15686
[4] Backus et al. (2015). *RSOS,* **2**: 140350
[5] Biewener & Daley (2007). *JEB,* **210**: 294