Modeling Musculotendinous Overuse Injury via Repetitive Eccentric Loading to Enable Accelerated Return-to-Duty

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MOTIVATION

Cumulative trauma disorders, particularly musculotendinous overuse injuries, significantly compromise U.S. military readiness, accounting for > 50% of all annual medical non-deployability. This creates an urgent clinical need for therapeutic strategies that accelerate healing and expedite return-to-duty. This project aimed to establish a reproducible musculotendinous overuse model to serve as a platform for screening FDA-approved pharmacological and rehabilitative interventions for use in forward-deployed environments.

HYPOTHESIS: A 4-week, high-frequency, subcritical eccentric loading regimen would induce calcaneal tendinopathy without concomitant eccentric-induced skeletal muscle injury.

METHODOLOGY

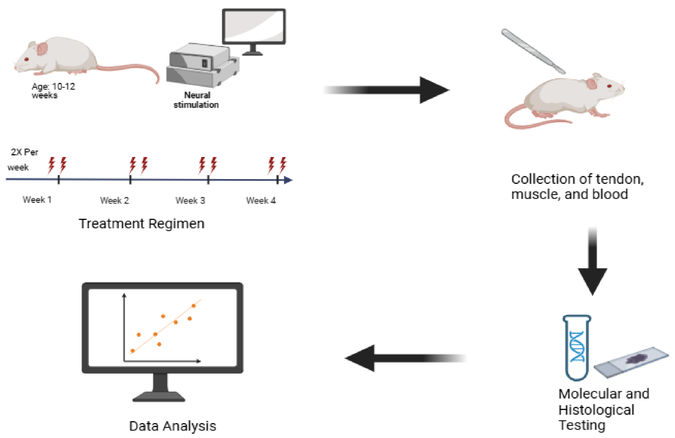

Figure 1: Male Sprague-Dawley rats (10–12 weeks old) underwent a neural-evoked training regimen twice weekly for 4 weeks. Animals were block randomized into cage activity (CTR), 30 isometric stimulations (ISO), 30 passive motions (PSM), or 30 eccentric contractions (ECC) of the plantar flexors. Isometric torque-frequency and torque-ankle flexion relationships were characterized. At 4 weeks post-training, gastrocnemius, Achilles tendon, and blood were harvested for biochemical and histological evaluation.

High-Frequency, Low-Intensity Neurally Evoked Eccentric Exercise Fails to Induce Calcaneal Tendinopathy Characteristic of Military Overuse Injuries

RESULTS

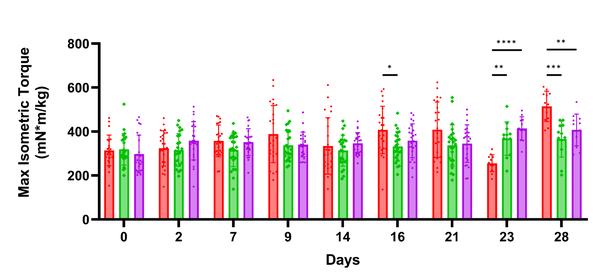

Figure 1. Figure 2. Maximum Isometric (Top) and Eccentric (Bottom) Torque for Isometric Training (red), Passive Motion (green), and Eccentric Training (purple) over the 28-day experimental time course. Colored bars represent the mean +/- SD with error bars, while *, **, *** represent P<0.05, P<0.01, and P<0.001 respectively.

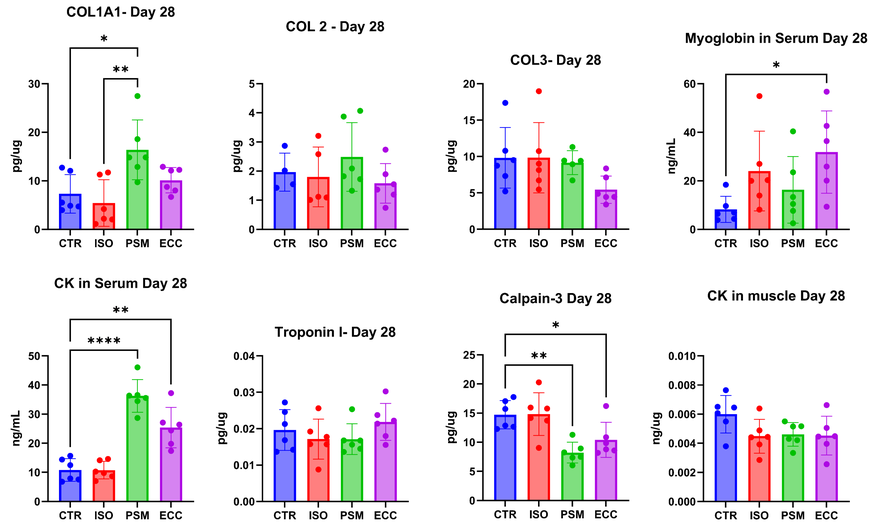

Figure 2: At Day 28, serum creatine kinase (CK) was significantly elevated in both the PSM and ECC groups compared to CTR ($P < 0.001$), while serum myoglobin was higher only in the ECC group versus CTR ($P = 0.037$). Qualitative histology revealed no overt disruptions to calcaneal tendon cellularity or morphology. Functional outcomes exhibited a moderate interaction with time ($\eta_p^2 = 0.19$); notably, isometric training reduced isometric tetani magnitude solely during the final week of testing. Otherwise, functional outcomes remained comparable between training paradigms across all timepoints.

Conclusions

- The 4-week eccentric loading regimen failed to induce isolated calcaneal tendinopathy.
- Ongoing studies are investigating other musculoskeletal injury models to induce calcaneal tendinopathy in both rats and swine to evaluate novel therapeutic strategies and rehabilitative interventions aimed at accelerating tissue healing and expediting return-to-duty.

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