Tracking Calf Muscle Structural Remodelling Across A 12-Week Eccentric Training

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Summary

Understanding skeletal muscle adaptation is key to optimizing training and rehabilitation. Our *in vivo* study tracks muscle-tendon structural remodelling over 12 weeks, showing individual responses to eccentric training, particularly in muscle volume and region-specific growth rates. These findings underscore the limitations of standardized protocols and contribute to a better understanding of muscle adaptation mechanisms and the development of individualized treatments for neuromuscular disorders, athletic performance, and regenerative medicine.

Introduction

The decline in skeletal muscle function due to neuromuscular disorders significantly affects quality of life. Slowing or preventing this deterioration requires targeted interventions. In this study, we examine how calf muscles adapt to multiweek eccentric training in young adults by assessing changes in muscle volume, length, force, and fatigability. By quantifying these adaptations, we aim to develop predictive models of muscle remodelling and the development of new robotic technologies, ultimately advancing rehabilitation strategies and clinical applications.

Methods

We assessed calf muscle adaptation in six healthy university students (3 male, 3 female, mean age 25 ± 4 years) by measuring muscle volume and length using 3D ultrasonography, following previously validated methods [1]. Muscle force and fatigability were assessed using dynamometry and high-density electromyography, applying a protocol previously developed by our group [2]. Subjects underwent a 12-week eccentric training program, performing training sessions on alternate days. Each session consisted of four sets of 8 to 12 controlled eccentric contractions using one-leg calf raises and one-leg donkey calf raises. To ensure progressive overload, additional weight was added throughout the program. Both legs were trained.

Results and Discussion

Preliminary results show that eccentric training significantly increased gastrocnemius medialis peak force after 12 weeks ($p<0.05$, Figure 1A). A trend toward increased muscle volume was observed (Figure 1B), while muscle length slightly decreased and tendon length increased (Figure 1C). Muscle fatigability—assessed via median frequency decline over 40 contractions at 50% MVC—showed subject-dependent variability, with some participants improving and others declining after training (Figure 1D).

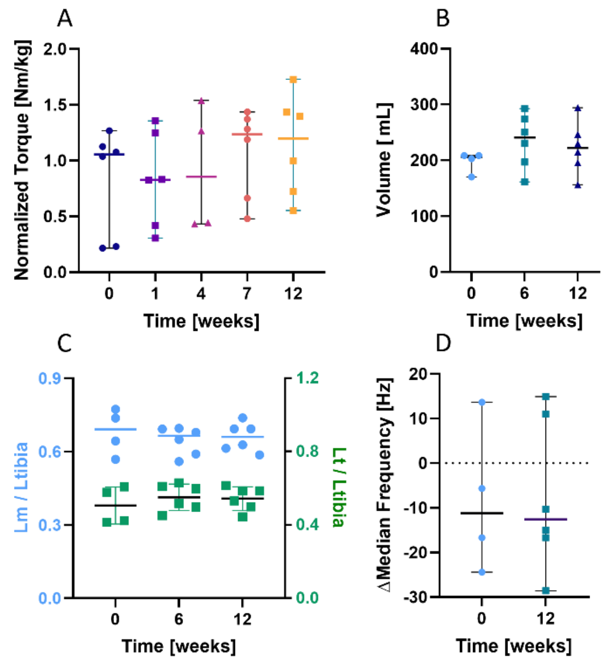

Figure 1: Individual variability in gastrocnemius medialis and Achilles tendon remodelling following 12 weeks of eccentric training. (A) Increased peak force. (B) Muscle volume. (C) Muscle length (left y-axis) and tendon length (right y-axis). (D) Muscle fatigability exhibited subject-dependent variability.

Conclusions

Our findings emphasize individual variability in muscle remodelling to eccentric training, reinforcing the need for personalized approaches in neuromuscular rehabilitation, athletic performance and regenerative medicine.

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References

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