Functional Hamstring Muscle Adaptations Following 9 Weeks of Eccentric Training

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Summary

Nine weeks of Nordic hamstring exercise (NHE) training increased eccentric strength, biceps femoris long head (BFlh), fascicle length, and muscle-tendon unit (MTU) length at peak torque during the NHE. Strength increases enabled greater knee extension, allowing the MTU to stretch further, largely attributed to increased fascicle lengthening. Eccentric training enables hamstrings to operate at longer lengths while maintaining optimal sarcomere lengths, reducing injury risk.

Introduction

Exercises like the NHE reduce hamstring injury risk by increasing muscle length and strength [1]. This study aimed to examine the adaptations in mechanics and muscle-tendon function that occur in response to NHE training. Dynamic changes in BFlh fascicle and MTU length were measured throughout the NHE before and after 9 weeks of training. These measures allowed us to assess contractile and tendinous tissue stretch during force production, reflecting the ability of the hamstring muscles to generate force at extended lengths.

Methods

Twelve recreationally active participants completed 9 weeks of NHE training. Eccentric knee flexor torque was measured using ankle-mounted load cells and the moment arm to the knee joint. BFlh fascicle length and MTU length were measured dynamically during the NHE, with fascicle length assessed via dual-transducer ultrasound and MTU length calculated using a regression equation based on hip, knee, and ankle joint angles from markerless motion capture. Knee flexor torque, BFlh fascicle length, and MTU length at peak torque during the NHE movement were compared between pre- and post-training. Changes in knee flexor torque, fascicle length, and MTU length at the point of peak torque during the NHE were analysed using linear mixed-effects models.

Results and Discussion

After 9 weeks of NHE training, peak eccentric knee flexor torque increased by 0.70 Nm/kg (51%; $p < 0.01$), which resulted from a greater knee angle at peak torque. This greater strength and knee extension allowed the MTU to reach a longer length post-training. At the point of peak torque during the NHE, BFlh fascicle length increased by 1.71 cm (24%; $p < 0.01$) and MTU length increased by 1.01 cm (3%; $p < 0.01$), with a larger proportion of the increased MTU stretch attributed to increased fascicle length compared to pre-training (Figure 1). Based on evidence of fiber length increases through serial sarcomerogenesis in response to the NHE training [2] we show that the peak fascicle strains, relative to optimum length, are likely to be similar post-training, despite the longer overall MTU stretch.

Conclusions

Our data indicates that NHE training allows the BFlh to increase its working range during the NHE. Coupled with changes in optimum fascicle length, as shown in our previous research [2], our data indicate that fascicles can work at longer MTU lengths but remain at sarcomere lengths close to optimal after 9 weeks of NHE training, potentially underpinning the protective benefits of eccentric training.

References

[1] Rudisill et al. (2023). *Am J Sports Med*, **51**: 1927-1942.
[2] Andrews et al. (2025). *J Sport Health Sci*, **14**: 100996.

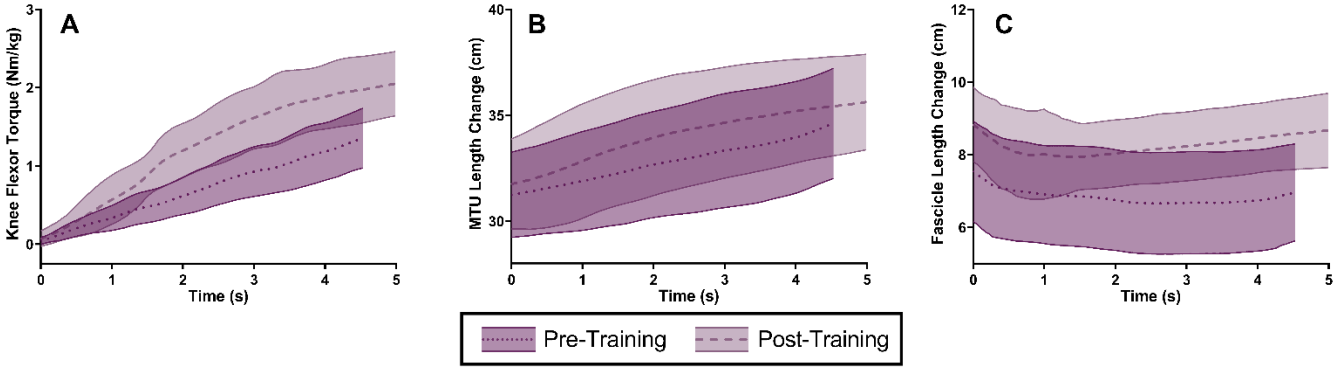

Figure 1: Changes in BFlh eccentric strength (A), MTU length (B), and fascicle length (C) during the NHE before and after 9 weeks of training. Significant increases in contractile and tendinous tissue stretch at peak torque were observed after training, allowing for greater force production.