All joints contribute to increased performance during leg multi-joint stretch-shortening cycles

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Summary

This study investigated how a stretch-shortening cycle (SSC) pattern increases performance during highly controlled submaximal bilateral multi-joint leg extensions. Net joint toques, muscle activity, fascicle behavior and tendon loads were assessed by inverse dynamics, electromyography, ultrasound, and shear-wave tensiometry [1], respectively. The findings highlight the performance-enhancing effects in each joint involved in leg-extension.

Introduction

Stretch-shortening cycles (SSC) are the most common type of muscle action in sports and daily locomotion. During the shortening phase of a SSC, muscle force, work, and power can increase by up to 50% compared with shortening contractions without prior stretch [2]. This SSC effect is well examined for single-joint movements but not for more complex multi-joint movements, such as leg extensions, which are highly relevant for locomotion.

Methods

Fourteen participants performed submaximal bilateral multi-joint leg extensions on a motor-driven dynamometer (IsoMed2000, D&R Ferstl GmbH, GER), including fixed-end, shortening (SHO), lengthening, and SSC contractions (velocity: 170 mm/s; ROM: 30–60° knee angle). Biofeedback of vastus lateralis muscle activity was used to ensure that each condition was performed at 30% MVC. Based on 3D motion capture and two synchronized 3-component force plates net joint torques at the ankle, knee, and hip were calculated by inverse dynamics. Potential SSC effects were assessed by comparing the force and torque output during the shortening phases of SHO and SSC.

Results and Discussion

Repeated measures ANOVA showed that vastus lateralis activity during the fixed-end phase before and after dynamic movement was consistent (pre: 28±1%, post: 28±1%; $p=0.373$) and unaffected by contraction conditions ($p=0.97$). During shortening, mean reaction force increased by 67±48% ($p<0.001$) during SSC compared with SHO (Figure 1). Further, net joint torques in the ankle, knee, and hip joints were also significantly increased during shortening of SSC compared with SHO (95±71%, $p<0.001$; 65±56%, $p<0.001$; 111±138%, $p=0.005$, respectively) (Figure 1).

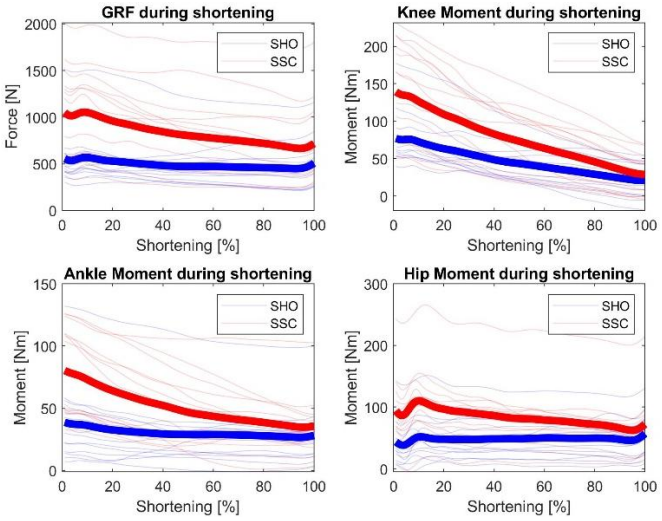

Figure 1: Individual and mean forces and net joint torques during the shortening phases of SHO (blue) and SSC (red).

During a holding phase post-shortening GRF was unaffected by contraction condition ($p=0.072$). Thus, history-dependent effects do not seem to play a role regarding the SSC effect. In further analysis using shear-wave tensiometry, we will examine whether similar effects can be observed for tendon load in the patellar and Achilles tendons.

Conclusions

The preliminary findings highlight the performance-enhancing effects in each joint involved in a leg-extension stretch-shortening cycle (SSC).

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References

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