Long-lasting effects of initial preload and preload conditions on successive stretch-shortening cycle performance

Tobias Göcking[1], Denis Holzer[1], Daniel Hahn[2,3], Florian Paternoster[4], Tobias Siebert[5], Wolfgang Seiberl[1]
[1]Institute of Sport Science, Department of Human Sciences, University of the Bundeswehr Munich, Neubiberg, Germany
[2]Human Movement Science, Faculty of Sport Science, Ruhr University Bochum, Bochum, Germany
[3]School of Human Movement and Nutrition Sciences, University of Queensland, Brisbane, Australia
[4]Biomechanics in Sports, Technical University of Munich, Munich, Germany
[5]Department of Motion and Exercise Science, University of Stuttgart, Stuttgart, Germany
Email: tobias.goecking@unibw.de

Summary

History-dependent effects in stretch-shortening cycle (SSC) contractions are not only limited to a single SSC. Since locomotion encompasses successive SSCs of the muscle-tendon unit (MTU), we investigated whether and how initial preload and preload condition at the onset of the first shortening affects the following SSC contractions. Our data shows that higher preload affects the first shortening and indicates that eccentric preload might have a longer-lasting effect for a second and third SSC than an isometric preload.

Introduction

Locomotion is characterized by successive MTU SSCs. In SSCs, history dependence and MTU-decoupling increase shortening performance (SSC effect) [1]. In single SSCs, it was shown that initially high eccentric preload is beneficial [2]. So far, few animal studies analyzed SSC effects in successive SSCs [3]. Thus, it remains unclear whether and how SSC effects last in successive human SSCs.

Methods

We analyzed ankle joint torque and MTU shortening work during submaximal electrically evoked plantar flexion contractions in three successive SSCs (N=9, ongoing study), with different initial preload conditions: 1) eccentric preload (*eSSC*); 2) high isometric preload (*hpSSC*); 3) low isometric preload (*lpSSC*). Initial preload of *hpSSC* was matched to eccentric preload in *eSSC* by an increased initial stimulation intensity. Torque at the onset (*bSho*) and end of shortening (*eSho*), as well as MTU shortening work were tested for each SSC-cycle (#1-3; Fig. 1, Top, green areas) by a 3x3 rmANOVA (#SSC-cycle vs. condition; $\alpha \leq 0.05$).

Results and Discussion

eSSC and *hpSSC* showed significantly higher torque than *lpSSC* at the onset of shortening (*bSho*) at #1 (p=.002, p=.008; Tab. 1) due to the stretch and stimulation-induced preload, respectively. Torque *bSho* of e*SSC* and *hpSSC* was similar at #1 (p = .458), thus preload was matched. For *lpSSC*, *bSho* increased from #1 to #2 (p<.001) and #3 (p=.028) (Tab. 1). For torque at the end of shortening (*eSho*), no significant effect was detected. Mechanical shortening work at #1 was significantly larger for *hpSSC* compared with *lpSSC* (p = .043; Fig. 1, bottom).

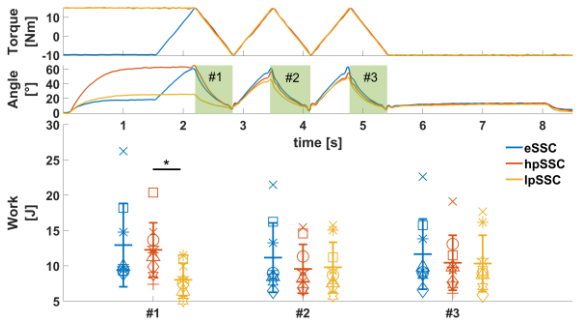

Figure 1: Top: Angle and torque data (n=1); Bottom: individual and mean (±SD) mechanical work (N=9); * significant differences.

Conclusions

Our data indicates that a high initial isometric preload affects mainly the first shortening phase of three consecutive SSCs without major impact on the shortening phases of successive SSCs #2 and #3. Whether eccentric preload induces longer-lasting enhanced performance needs further data collection to increase sample size for more statistical power.

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References

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Table 1: Mean (±SD) of Torque at the onset (*bSho*) and the end (*eSho*) of shortening for SSC cycles (#1 to 3) for conditions *eSSC*, *hpSSC* and *lpSSC*. * significant difference to e*SSC*, † significant difference to *hpSSC*, _ significant difference to #1 of *lpSSC*.

	#1			#2			#3		
	eSSC	*hpSSC*	*lpSSC*	*eSSC*	*hpSSC*	*lpSSC*	*eSSC*	*hpSSC*	*lpSSC*
bSho [Nm]	65.1±15.6	76.6±22.2	35.3±10.3*†	66.9±18.4	58.3±15.9	57.6±15.1	61.4±17.4	56.3±17.6	57.0±18.6
eSho [Nm]	20.7±12.3	14.0±5.5	15.7±7.3	19.4±9.7	14.9±5.9	15.5±6.0	18.2±8.8	14.6±7.4	16.4±7.4