EFFECT OF COUPLING TIME ON STRETCH SHORTEN CYCLE FORCE ENHANCEMENT FOR MAXIMAL KNEE EXTENSIONS ON AN ISOVELOCITY DYNAMOMETER

[1]Mickael Begon, [2]Steph Forrester and [3]Matt Pain

[1]Université de Montréal, Canada, email: mickael.begon@umontreal.ca, web: www.kinesio.umontreal.ca/,
[2]STI, Loughborough University, UK; email: s.forrester@lboro.ac.uk; web: www.sports-technology.com/,
[3]SSES, Loughborough University, UK; email: m.t.g.pain@lboro.ac.uk; web: www.lboro.ac.uk/departments/sses/

INTRODUCTION

The Stretch Shorten Cycle (SSC) occurs when an active musculotendinous unit is forcibly stretched before it shortens, giving rise to increased levels of force production. There are a number of mechanisms suggested for this phenomenon (discussed in a review edition of the Journal of Applied Biomechanics, Issue 4 volume 13, 1997) but the exact contribution to overall performance is still equivocal. Introducing a delay in the Coupling Time (CT) between the eccentric and concentric actions in a SSC reduces the effect of the SSC enhancement in an exponential manner [1].

In most natural motions maximal activation is not necessarily present throughout the entire SSC, they often occur over short time frames and have large changes in velocity. All these contribute to the difficulty in comparing results between SSC experiments with the properties of stretching and shortening muscle fibres that are normally performed under more controlled conditions. The aim of this research is to examine the effect of CT on SSC enhancement during well controlled pseudo-isovelocity conditions with maximal voluntary activation.

METHODS

Seven athletic subjects (22.4 ± 0.6 years; 178 ± 12 cm; 79.8 ± 8.7 kg) gave informed consent. Maximum voluntary knee extensions were conducted on a CON-TREX dynamometer at three velocities (30°s^{-1}, 60°s^{-1} and 100°s^{-1}). The first set of trials were maximum effort eccentric-isometric-concentric contractions for six isometric coupling times (0.07, 0.3, 0.6, 1, 2, 4 s) at each velocity. Initial knee angle was 10° of flexion and subjects were asked to maximally resist forced flexion through a 70° range of motion and to continue pushing maximally throughout the isometric and concentric phases. The second set of trials were maximum effort isometric-concentric contractions using the same isometric angle (held for 2 s) and concentric velocities as in the first set. The torque at 10°, 20° and 30° into the concentric movement was evaluated for each trial and normalised based on the values for the shortest coupling time (0.07 s) at that velocity.

RESULTS AND DISCUSSION

In the eccentric-isometric-concentric trials normalised concentric torque appeared to decrease exponentially with increasing isometric coupling time (Figure 1, Eqn. 1) with a half life of 0.7 seconds.

$$\frac{T}{T_{ct=0.07}} = 0.759 + 0.259\exp(-1.002ct) \qquad \text{Eqn. 1}$$

As other studies have shown [2], the improvement in SSC performance is not as great when compared to isometric preload as when compared to purely concentric contractions.

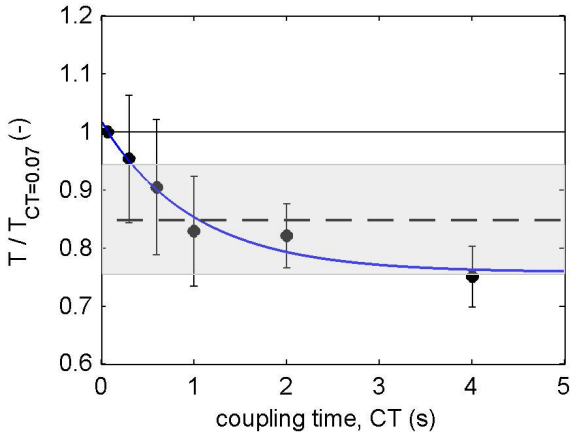

Figure 1: Normalised concentric torque (normalised to 0.07 s CT value) versus CT. Black circles are mean ± SD from eccentric-isometric-concentric trials averaged over all velocities, all concentric positions and all subjects. Solid blue line is the exponential fit. Dashed line and shaded region are the mean ± SD from isometric-concentric trials averaged over the same conditions.

The SSC performance was only significantly better than the isometric-concentric performance for the shortest coupling times and was worse at the longest CT. The exponential decay could be an artifact from: the first 2 or 3 data points decreasing in value as a short term stretch related enhancement dropped off; points 3, 4 and 5 being constant and approximately equal to the isometric-concentric trials; and the last point dropping off due to greater fatigue within the SSC trials. Maximal effort in the SSC trials would have been required for up to 7 seconds but only for up to 3 seconds in the isometric-concentric trials. These results suggest that improvements due to the active stretching last no longer than 1 s. However, the exact load at the start of the concentric phase has not been explicitly accounted for and the EMG activity of the quadriceps also needs quantifying.

CONCLUSIONS

Torque appears to decay exponentially with increasing CT. A SSC for maximum voluntary knee extensions can have a significant effect over isometric preload on the concentric torque generation, but only for low CT.

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REFERENCES

1. Wilson GJ, et al., *Med Sci Sport Exerc.* **23**, 364-370, 1991.
2. Walshe AD, et al,. *J Appl Physiol.* **84**, 97-106, 1998.