CENTRAL AND PERIPHERAL CONTROL OF MUSCLE STIFFNESS IN HOPPING

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INTRODUCTION

In stretch-shortening cycle (SSC), a transition period from the eccentric to the concentric phases is called coupling time (Ct). If duration of Ct increases, the release of the elastic energy in the concentric phase would decrease. Thus, minimizing Ct is important for the elastic energy utilization in SSC.

Although Ct depends on the total movement time [2], the mechanisms responsible for this phenomenon were not well-known. Lansel-Corbeil and Goubel (1990) reported that an increase in muscle stiffness during the eccentric phase would reduce Ct. Therefore, it is hypothesized that stiffness regulation during the eccentric phase could be key to solve above-mentioned problem.

The purpose of this study was to investigate the neural control mechanism of the triceps surae to reduce Ct during hopping.

METHODS

Seven male subjects performed two-legged hopping at the preferred and the lowest frequency (PF, LF, respectively). The subjects determined these frequencies voluntarily. To differentiate Ct, two different ground contact time were manipulated during stance phase at each frequency: preferred and the shortest possible time (PCT and SCT, respectively).

An ankle angle was measured by a goniometer to calculate Ct, which was computed as the time period of 5 % threshold levels above the minimum ankle angle [1]. The surface electromyography (EMG) activities of the medial gastrocnemius (MG) and soleus (SOL) muscles were recorded with telemetric system. Obtained EMG signals were amplified, full wave rectified, and then integrated over the fixed interval of 20 ms. All data were compared PCT with SCT conditions.

RESULTS AND DISCUSSION

As shown in Table 1, we could differentiate Ct by manipulating ground contact time in same hopping frequency.

The most important finding of this study was that increased pre- and post-landing EMG activity was observed in SCT conditions at each frequency (Figure 1).

Table 1: Mechanical data for PCT and SCT.

	Preferred frequency		Lowest frequency	
	PCT	SCT	PCT	SCT
Hopping frequency (Hz)	2.12 ± 0.1	2.11 ± 0.08	1.87 ± 0.2	1.87 ± 0.2
Ground contact time (ms)	238 ± 32	203 ± 32**	210 ± 33	198 ± 28**
Coupling time (ms)	39 ± 15	32 ± 9 **	33 ± 11	29 ± 10**

** $p < 0.01$

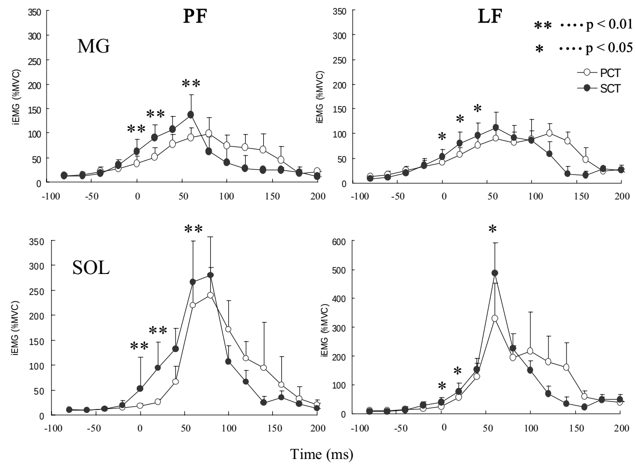

Figure 1: Representative EMG activities during hopping. The records were lined up with ground contact as reference (Zero time).

EMG activity observed at pre-landing was thought to be feed-forward motor program that made in central nervous system [3]. In addition, post-landing EMG is mentioned as short-latency stretch reflexes triggered by dorsiflexion [5]. Both EMG activities have an effect to regulate muscle stiffness during the eccentric phase [3, 5].

Considering that an increase in muscle stiffness during the eccentric phase would reduce Ct [4], increased EMG activity in SCT conditions can be interpreted as adaptations to regulate muscle stiffness for reduction of Ct by central and peripheral nervous system.

CONCLUSIONS

Neuromuscular control of the triceps surae to reduce Ct was investigated. These results clearly show that stiffness regulation by central and peripheral nervous system contributes to reduce Ct.

REFERENCES

1. Aura O., Komi PV. BIOMECHANICS X-A, 507-501, 1987.
2. Bosco C., Rusko H. Acta Physiol Scand **119**, 219-224, 1983.
3. Golhofer A., Kyrolainen H. Int J Sports Med **12**, 34-40, 1991.
4. Lansel-Corbeil G., Goubel F. J Biomech **23**, 121-126, 1990.
5. Voigt M., et al. Acta Physiol Scand **163**, 181-194, 1998.