THE EFFECT OF FATIGUE ON THE CONTROL OF TARGETED ISOMETRIC DORSIFLEXION IN HUMANS

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INTRODUCTION

Fast and target orientated movement is common in daily life and in sports. Skeletal muscle fatigue is defined as the failure to maintain required or expected torques or the increasing efforts to maintain the same torque output level (2). Previous study has shown that torque of maximal voluntary contraction (MVC) declined and the contraction and relaxation prolonged after fatigue (1). It is possible that the ability of movement control after fatigue declines by fatigue, especially in fast movement. Co-contraction is one form of the controlling strategies defined as the simultaneous recruitment of two muscles. Since fatigue results in slowing of contractile speed and increase recruitment during submaximal isometric contractions (3), the error of movement, especially fast movement, should increase. It is not clear whether this increased movement error can be corrected by adjusting the control pattern of agonist- antagonist muscle pairs.

METHODS

10 volunteers with averaged age 22.9 ± 1.97 participated. Subjects sat on a rigid chair with one foot fixed firmly on the platform of the torque measurement system (fig.1). The signal from the force transducer as well as a target line was displayed on a screen where subjects can clearly view. The electromyography (EMG) signals were recorded from soleus and tibia anterior muscle (fig.2).

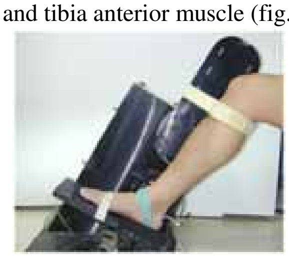

Fig1. Torque measurement system

Fig2. Tibialis anterior and Soleus EMG electrode placement

The test was started with 5 MVC of dorsiflexion. Fatigue was defined as subjects' torque was hard to reach 50% MVC. 40% of the MVC was calculated to set the target line. Following the MVC test, the subject conducted 5 fast and 5 slow isometric dorsiflexions with peak torque just hitting the target line before and after TA fatigue. The systematic errors of torque generation and co-contraction ratio of EMG firing were calculated. Two-way repeated-measures of ANOVA was used to examine the effects of fatigue and speed on systematic error, co-contraction ratio. A significance level of $p < 0.05$ was used.

RESULTS AND DISCUSSION

In this study, we observed the higher systematic errors and co-contraction ratio in the fast contractions (Table 1 & 2). We expected participants used co-contraction for improving the performance of force generation.

Table1. The mean and Std. of Systematic error in pre-test and post-test in the fatigue and control session.

	Systematic error (%)			
	Experimental group		Control group	
	fast	slow	fast	slow
Pre	11.69±4.80	$4.55\pm2.16^{*}$	9.10±3.91	$3.38\pm0.99^{*}$
Post	$24.31\pm6.53^{\dagger}$	$10.27\pm4.10^{*\dagger}$	8.16±3.77	$4.65\pm1.92^{*}$

Table2. The mean and Std. of co-contraction ratio of the TA and Sol in the pre-test and post-test in the fatigue and the control session.

	Co-contraction ration (%)			
	Experimental group		Control group	
	fast	slow	fast	slow
Pre	0.81±0.14	$0.67\pm0.24^{*}$	0.76±0.19	$0.67\pm0.28^{*}$
Post	0.82±0.10	$0.80\pm0.20^{*\dagger}$	0.80±0.15	$0.58\pm0.34^{*}$

If the phasic activation associated with the accuracy control of the force, it is interesting to know if the pattern switched to reduce error after fatigue. According to the result (Table2), the co-contraction ratio was only increased in the slow contractions but was unvaried in the fast contractions. This increase of the co-contraction ratio was parallel to the change of systematic error (Table1). After fatigue, the magnitude of the systematic error increment was higher in the fast contractions than in slow contractions indicating the accuracy was adjusted in the slow contractions. It is possible that the change of co-contraction ratio in the slow contractions was for increasing the accuracy of movement.

CONCLUSIONS

Our results supported that the systematic of force generation increased after fatigue in both the fast and slow isometric contractions. The slow isometric contractions had smaller increment in the systematic error related to the change of the agonist-antagonist activation patterns.

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