HIP POSTURE AND PRE-ACTIVATION LEVELS MODULATE REFLEX CONTRACTIONS ELICITED BY KNEE LIGAMENT LOADING

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INTRODUCTION

We have previously shown that muscle contractions can be elicited by the application of valgus perturbations at the human knee (Dhaher et al., 2003). Based on several experimental qualifiers, we concluded that these contractions are reflex in nature and are mediated by periarticular tissue afferents. In this study we investigated the effect of posture (defined as change in hip angle) and neural state (defined by the pre-activation levels in knee muscles) on the intensity of this class of reflex. We hypothesize that both posture and neural state play a significant role in the modulation of periarticular tissues afferents mediated reflex at the human knee.

METHODS

A total of 9 normal subjects were tested. The experimental set-up and procedure has been thoroughly presented previously (Dhaher et al., 2003) and will be briefly described below. After securing the subject’s knee in a single-degree of freedom servomotor system, the joint was pre-loaded at 4° in the valgus direction to ensure initial stretch of passive joint tissues. Each subject was asked to provide two knee muscle co-activation levels as a percent of the varus passive torque (VPT) (0, 5-10%). The VPT was measured with no muscle contractions using a load cell attached to the servo system. Multiple 8° rapid (60°/sec) valgus step inputs (stretch-hold and release paradigm; see Dhaher et. al. 2003) were applied at the knee joint at two different hip flexion angles (90° and 50°) repeated at both co-activation levels. EMG activity was recorded from a flexor, semitendinosus (ST), and an extensor, vastus medialis longus (VML) using surface electrodes. The elicited sustained reflex response (SR) measured over 500 ms, was the EMG activity during the hold period of the valgus position stimulus (see Dhaher et. al. 2003). The SR was quantified as follows:

\[ SR = EMG_{\text{reflex mean}} - EMG_{\text{baseline mean}} \]

where \( EMG_{\text{reflex mean}} \) is the time average of the rectified and smoothed EMG during the reflex activity and \( EMG_{\text{baseline mean}} \) is the time average of the baseline activity calculated over 500 ms prior to the onset of the mechanical perturbation.

RESULTS AND DISCUSSION

The sustained reflex response (SR) amplitude of both the VML and ST muscles exhibited a statistically significant increase (p<0.001) with increase in hip flexion angle. Specifically, in Figures 1-4 we observe a significant increase in SR activity of both muscles across all four subjects with change of hip flexion angle. Seven out of nine subjects showed a similar trend in the extensor muscle (VML) (p<0.001) and nine out of nine for the flexor muscle (ST) (p<0.001). As shown in Figures 1 and 2, for both hip angles (90° and 50° of hip flexion) this dependency was a function of muscle activation prior to the perturbation. Pre-activation of knee extensors exhibited both an increase (Figure 1) and decrease (Figure 2) as a function of pre-activation levels. This was also observed in the knee flexors.
(Figures 3 and 4). However, for a given hip angle and across all nine subjects, six of the subjects demonstrated an increase (p<0.001) of the extensor and flexors reflex intensity as a function of knee muscles pre-activation level.

Figure 1: SR reflex activity of VML as a function of hip angle and pre-activation level for subject DK.

Figure 2: SR reflex activity of VML as a function of hip angle and pre-activation level for subject LK.

SUMMARY

Our preliminary results show that hip extension results in an increase of the sustained reflex response. The observed increase was consistent in both the flexor and extensor muscles. Our data also showed that the pre-activation state of knee muscles significantly alters the intensity of muscle contractions mediated by periarticular tissue afferents. This effect can be attributed to one of three potential factors: 1) vestibular input, 2) hip joint proprioceptors input, and 3) input from muscle spindles of the pre-activated muscles. All these factors taken together indicate that other sensory layers derived from global sensory modalities could potentially influence the local varus/valgus-stabilizing role of reflexes mediated by the joint’s periarticular tissue afferents.

Figure 3: SR reflex activity of ST as a function of hip angle and pre-activation level for subject DZ.

Figure 4: SR reflex activity of ST as a function of hip angle and pre-activation level for subject DI.

REFERENCES

Dhaher et al. (2003), J. of Biomechanics, 36(2),199-209

ACKNOWLEDGEMENTS

This work was supported by the Dr. Ralph and Marian C. Falk Medical Research Trust, the National Institute of Health (AR46422-02; 5P60AR30692; ST32HD07418), and the Whitaker Foundation.