MUSCLES' CO-ACTIVATION IN A STATIONARY LIMB ALTERES ACCORDING TO THE MOVEMENT OF OTHER LIMB

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Abstract: This paper reports an interesting phenomenon of observable muscle co-contraction in stationary limbs according to the movement pattern in an oscillating limb. In the experiments the subject's electromyography signals of biceps and triceps of both left and right arm are recorded. Two experiments were conducted which are different in the posture of left and right arm. The first experiment is conducted when both forearms are in upright posture. In the second experiment though, the right forearm is moving. It was observed that the EMG of both biceps and triceps (i.e. co-activation) of the stationary limb follow that of the opposite moving limb. The reason can be addressed by the necessity of stabilizing the stationary limb when one executes motion in the counter limb. Moreover it can possibly be due to post-intention, pre-motion brain activities that may fire the muscles of both limbs similarly.

1 INTRODUCTION

Hogan (Hogan, 1984) emphasized how antagonist muscle's co-activation in forearm's upright posture might help with the posture control. He showed that the co-activation sets the mechanical impedance of the elbow joint and postulated that this is what the co-activation is meant to do. Later Burdet (Burdet et al, 2001) proved that human learns to stabilize unstable dynamics by optimizing mechanical impedance. Conclusively, unstable tasks require impedance optimization and the impedance is set by co-activation of a pair of muscles (i.e. agonist and antagonist). Is this co-activation only considerable in unstable dynamics? A recent study (Darainy et al, 2008) on EMG patterns of dynamic learning of stable tasks also reveals a considerable portion of co-activation. Therefore, the CNS co-contracts the antagonists not only in unstable dynamics, but also it does in all tasks (Mousavi et al, 2009).
So far it was proven that this co-activation or mechanical impedance adjustment is required from the perspective of controlling one limb (Hogan, 1984) and (Burdet et al, 2001). However in this paper we report a seemingly meaningful co-activation in a stationary limb when the counter limb is moving.

2 EXPERIMENTAL OBSERVATION

The co-activation of antagonist muscle is linking and relating to optimal impedance. Co-activation occurs in both stable and unstable tasks regardless of the fact that in stable tasks impedance is not as necessary.
In an experimental study we recorded the EMG of biceps and triceps of both arms during two tasks including:

- Both forearms were in upright posture (stationary)
- Left forearm is in upright posture (stationary)Right forearm was moving (flexor-extensor)

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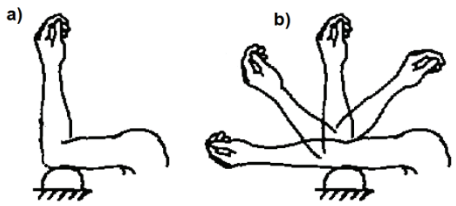

Figure 1: a) upright stationary posture b) elbow flexion-extension.

The EMG signal when both forearms are in upright posture (Figure 1.a) is shown in Figure 2. In Figure 3, however, we find the same muscles' EMG when left arm remains upright stationary but the right forearm moves according to Figure 1.b.

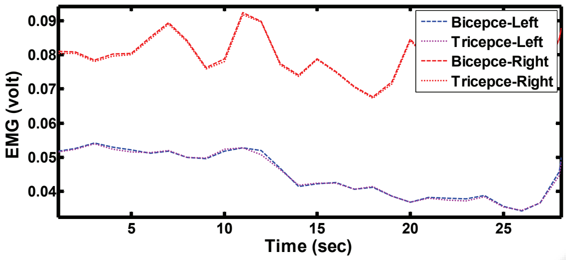

Figure 2: EMG of right and left arm when both arms are upright stationary.

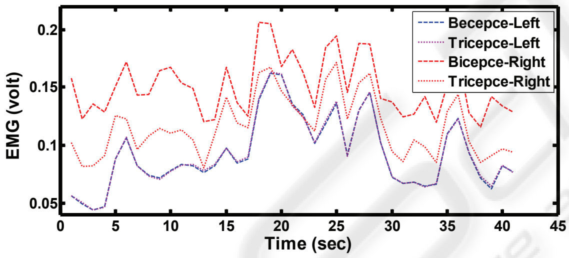

Figure 3: EMG when left arm remains upright stationary and right arm moves.

Comparing the two situations we can observe that the EMG in the stationary limb (left arm) is considerably affected by that of the moving limb moreover biceps and triceps of the stationary arm are co-activated with almost the same amount.

3 HYPOTHESIZING

It can be postulated that the source of the co-activation of the muscles in the stationary limb is to feel secure about the performance of the moving limb. If the stationary limb remains more stable against possible perturbations, in case of perturbation less correction and hence computation would be needed. Then the task which is intended to be done by the opposite limb is performed with more comfort and concentration. In a word, we spend more energy to fire the muscles of a stationary limb so as to avoid excessive computing.

4 APPLICATION

Stroke patients mostly suffer from hemiplegia; they lose some of the motor neurons with their associated information that leave them with one side affected and one side intact. Recovery rate has been reported significant when a stroke patient move the healthy limb and a robot imitating the motion apply the same pattern to the affected limb (Burgar et al, 2000), (Luft et al, 2004), and (Hesse et al, 2003). The reason why this accelerates the recovery is not clear yet. However, our finding might help address this question.

We observed that when one moves a limb, the CNS also sends some signals to the other limb even if it is in a static posture. The signal might not be as powerful to move it or more probably the signal might not meant to move it; instead it could be to make sure that the resting limb is going to stay in the static posture.

Now let's imagine that every time the stroke subject's arm is driven by the robot there have been some signals to fire the muscles already. That can be the reason why a stroke patient's recovery process is faster when they move undergo mirror image movement enabler system.

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