QUANTIFYING PROPRIOCEPTIVE REFLEXES DURING POSTURE TASKS

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INTRODUCTION

Recent studies revealed that during posture tasks the strength of proprioceptive reflexes adapts to the bandwidth of the (force) disturbance (Van der Helm et al., 2002) and to the virtual dynamics of the (haptic) manipulator (De Vlugt et al., 2002). Both studies use the mechanical admittance, i.e. the dynamic relationship between force and position, to quantify the strength of the proprioceptive reflexes. This study uses the dynamic relationship between position and EMG in addition to the mechanical admittance to provide support for the previous studies and to obtain a more detailed model for the proprioceptive reflexes.

METHODS

The experiments consist of a series of trials; 30 seconds each. The subject has to minimize the position deviations of the handle, while random continuous force disturbances are applied (see Fig. 1). To provoke different reflexive settings the damping of the manipulator is altered over the trials or the frequency content of the force disturbance is altered.

During a trial the handle position, the force at the handle, and the EMGs of four relevant shoulder muscles are measured. The EMGs are lumped and all signals are transformed to the frequency domain to obtain the spectral densities. Frequency response functions (FRFs) are estimated by dividing the appropriate spectral densities. To quantify the reflexes the FRFs are fitted by a model.

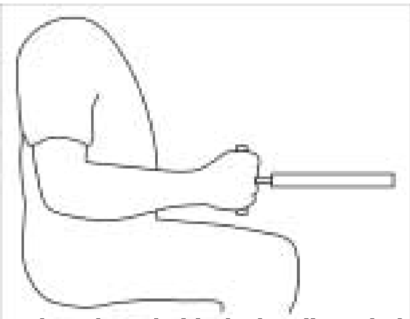

Figure 1: The subject holds the handle with the right hand, and can move the handle for- and backwards. Subjects are asked to *'maintain position'*, while force disturbance are applied.

RESULTS AND DISCUSSION

The task given to the subject is '*minimize deviations*', an unambiguous task resulting in co-contraction of all muscles around the shoulder girdle (no significant difference in muscle activation between conditions). Figure 2 shows the FRFs of the human arm, interacting with (150 Ns/m) and without external damping. From the admittance (left) it can be seen that for low frequencies (<2 Hz) the admittance is decreased when external damping is present and that a resonant peak occurs around the eigenfrequency (±3 Hz). Both are likely the result of increased reflexes, giving more stiffness at the cost of oscillatory behavior, which results from the neural time-delays going with reflexes. The FRF between position and EMG (right) supports the finding that reflexes are increased as the gain increases with external damping. Having this relationship a more detailed model of proprioceptive reflexes can be build, containing Golgi tendon organs and muscle spindles, combined with short and medium latency reflexes.

SUMMARY

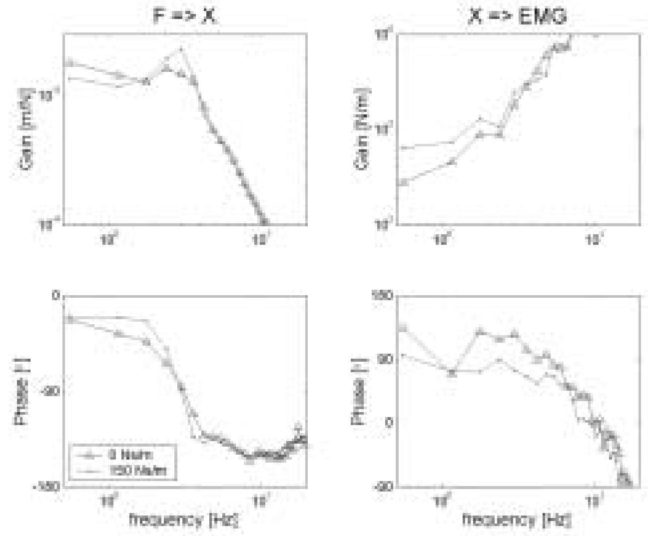

Figure 2: Left: the admittance of the human arm; right: the FRF between position and EMG**.**

With the presented method it is possible to measure the mechanical admittance and dynamic relationship between muscle activation and position accurately. Furthermore it is demonstrated that the strength of proprioceptive reflexes is adaptable and that the reflex strength increases, when the human arm interacts with highly viscous environment.

REFERENCES

De Vlugt E, Schouten AC, Van der Helm FCT (2002) *Biol Cybern* **87**: 10-26.
Van der Helm FCT et al. (2002) *J Neurosci Meth* **119**: 1-14

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