COMPARISON OF FINGER FORCE ENSLAVING AND SHARING BETWEEN MVF AND OSCILLATORY FINGER FORCE PRODUCTION TASKS

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INTRODUCTION

Finger interaction indices such as finger enslaving calculated from experiments of multi-finger maximum voluntary force (MVF) production task have been used to model the inter-connections between finger forces and the central nervous system (CNS) commands to the fingers. However, it has not been studied whether different finger force production tasks would induce different inter-connections. This study aimed to investigate the effects of force production patterns (maximum force production and oscillatory force production) and finger force direction (flexion and extension) on the finger interaction indices, such as force enslaving (FE; involuntary force of non-task fingers), and force sharing (FS; percentage contributions of finger forces to the total force during a four-finger force production task).

METHODS

Apparatus Four two-directional (tension and compression) force sensors with amplifiers (Models 208 M182 and 484B, Piezotronics, Inc.) were used to measure isometric finger flexion and extension forces. The frame was attached to an aluminum panel with a vertical slit. C-shaped aluminum thimbles were attached on the bottom of each sensor. The frame was tilted at 25^o with respect to the antero-posterior axis such that all finger joints were slightly flexed when the distal phalanges were positioned inside the thimbles. The forearm and hand was fixed in a brace.

Procedure Sixteen healthy and right handed young adults (8 females and 8 males) were asked to insert each finger tip of the right hand into a thimble and were instructed to produce two main tasks: (a) maximum flexion and extension isometric force with one finger (I- index, M-middle, R-ring, and L-little) and all four fingers (IMRL) at a time over several seconds; (b) fast and slow oscillatory (flexion and extension) finger force production (oscillation task) following a auditory feedback metronome (60 and 120 bpm) with one finger (I, M, R, L) and all four fingers (IMRL). The forces produced in either direction were 20% of the task finger's MVF. The conditions lasted 20 seconds (for a total of 20 cycles).

The forces of both instructed finger and non-instructed fingers were recorded (Figure 1). Indices of digit interaction such as FE and FS were computed for the MVF tasks. For the oscillation tasks, gain of frequency-response function (input: task finger force, output: non-task finger forces) was used as indices of finger interaction.

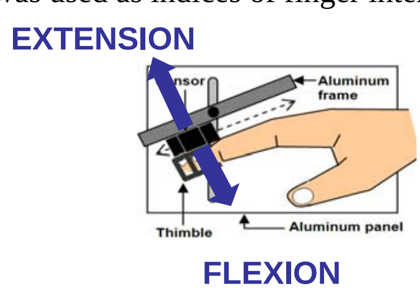

Figure 1: Experimental setup

RESULTS

When compared two force production patterns (peak and oscillatory), FE during MVF task was greater than both conditions of oscillation tasks (60 and 120bpm). While FE was not significant different between two oscillatory conditions (Figure 2), FE in extension direction was in general greater than in flexion direction. No significant differences for FS were found when compared force production patterns (peak and oscillatory) and directions (flexion and extension). The middle finger showed higher contribution during four-finger task (Figure 3).

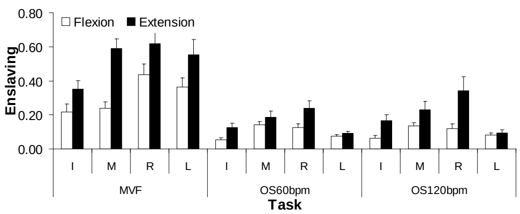

Figure 2: Force enslaving during flexion and extension in MVF, 60bpm and 120bpm oscillation tasks

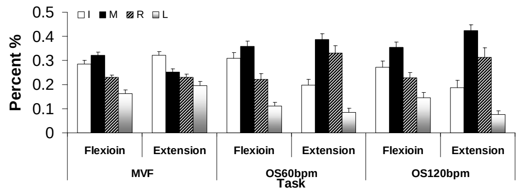

Figure 3: Force sharing during flexion and extension in MVF, 60bpm and 120bpm oscillation tasks

CONCLUSIONS

Our results showed that the FE indices are affected by force production pattern and by the finger force direction. We suggest that different inter-finger matrix (enslaving matrix) should be used for modeling of different finger force production tasks.

REFERENCES

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Table 1: Force Enslaving ratio

	MVF				OS60bpm				OS120bpm			
	I	M	R	L	I	M	R	L	I	M	R	L
Flexion	0.22±0.05	0.24±0.04	0.43±0.06	0.36±0.05	0.05±0.01	0.14±0.02	0.13±0.02	0.07±0.01	0.06±0.02	0.13±0.02	0.12±0.03	0.08±0.01
Extension	0.35±0.05	0.59±0.06	0.62±0.09	0.55±0.09	0.12±0.03	0.18±0.04	0.24±0.04	0.09±0.01	0.17±0.04	0.23±0.05	0.34±0.08	0.10±0.02

Table 2: Force Sharing ratio

	MVF		OS60bpm		OS120bpm	
	Flexion	Extension	Flexion	Extension	Flexion	Extension
I	0.285±0.014	0.321±0.015	0.308±0.025	0.198±0.023	0.272±0.026	0.186±0.031
M	0.321±0.014	0.252±0.011	0.358±0.021	0.387±0.024	0.354±0.021	0.423±0.024
R	0.230±0.009	0.230±0.013	0.223±0.023	0.330±0.030	0.227±0.023	0.314±0.039
L	0.164±0.014	0.197±0.015	0.111±0.016	0.085±0.016	0.147±0.021	0.077±0.015