CERVICAL SPINAL CORD INJURY PATIENTS SHOW INVOLUNTARY FORCE PRODUCTION IN PARALYZED FINGERS DURING OTHER FINGER FORCE PRODUCTION TASKS

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INTRODUCTION

This study investigates finger enslaving and force deficit phenomena in individuals with cervical spinal cord injuries. Finger enslaving is the involuntary production of force by a finger not meant to move. Force deficit phenomena occur when the maximum force produced by the movement of the four fingers is less than the sum of each individual finger's maximum force. Impaired hand dexterity severely limits the daily living of individuals with cervical spinal injury (SCI) [1,2]. Individuals with SCI often have limited function in hands and upper extremities. In this study, we selectively recruited persons with SCI who have one "paralyzed" finger (a finger unable to produce isometric pressing force) and three other "functioning" fingers (fingers able to produce isometric pressing force).

METHODS

Subject: Eight male individuals with a cervical spinal cord injury (SCI; age: 35.9 ± 14.0 yrs; history of SCI: 11.8 ± 10.4 yrs; American Spinal Injury Association Motor Score: 47.5 ± 12.2) with partial paralysis of fingers participated in this study, as did six other age and gender matched control subjects (CTR; 35.7 ± 9.9 yrs). Each SCI subject had paralysis in only one of the four fingers of the right hand.

Equipment: Four force sensors with amplifiers for each finger were used for data acquisition. The sensors were mounted on a customized aluminum frame.

Experimental Procedures: Subjects performed five of the maximum voluntary force (MVF) tasks for isometric finger-tip pressing. Each task finger was represented by one of five conditions. I, M, R, and L designated single-finger tasks and IMRL designated four-finger tasks.

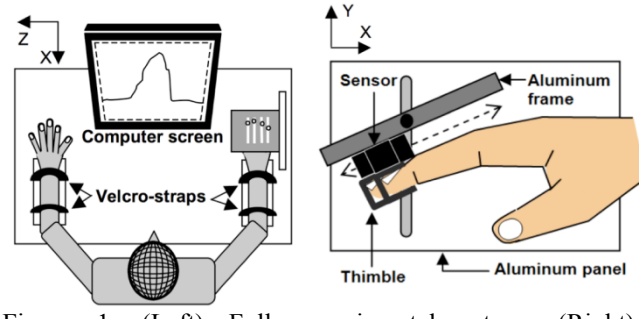

Figure 1. (Left) Full experimental set-up. (Right) Experimental set-up for the right hand.

Data Analysis: The following variables were calculated.

1. Maximum voluntary force (MVF): The peak magnitudes of both individual finger and four-finger forces were calculated.
2. Finger force enslaving (EN) and force enslaved (ED): The average of the non-task finger forces during a single-finger MVF tasks was quantified as evidence of finger force enslaving of the task finger (EN). The average of the forces produced by non-task fingers during the tasks of the other fingers was quantified as finger force enslaved (ED).
3. Force Deficit (FD): The force deficit for each finger was calculated by taking the difference between the sum of a single finger's MVF during single finger tasks and the four-finger MVF during the four-finger task.

RESULTS AND DISCUSSION

Finger force enslaving (EN) and Finger force enslaved (ED): During force production tasks utilizing the paralyzed fingers, non-task functioning fingers produced significant involuntary forces. The finger force enslaving (EN) of paralyzed fingers seen in subjects with SCI was smaller than the EN of the CTR ($p<.05$) and the EN of the functioning fingers of subjects with SCI. However, there was no significant factor effect or interaction effect in ED values.

Finger force surplus in SCI: The sum of individual finger MVF values was greater than the four-finger MVF value in the CTR group (Fig. 2A), demonstrating force deficits (FD). However, the opposite was observed in the SCI group. The sum of individual finger MVF values was smaller than the four-finger MVF value for both paralyzed fingers and functioning fingers, demonstrating there was a "force surplus" rather than a force deficit ($p<.05$).

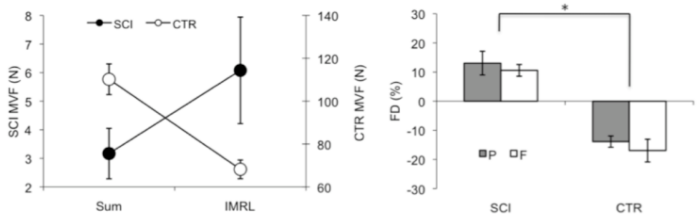

Figure 2. Maximum voluntary force (MVF) and force deficit (FD) in SCI and CTR. P: paralyzed fingers, F: functioning fingers.

CONCLUSIONS

The maximum force during the four-finger task was greater than the sum of the individual finger forces during single finger tasks in the SCI group. This was reflected by a positive force deficit — a "force surplus." Although paralyzed fingers of SCI patients can not produce forces or movements, the paralyzed finger may benefit from exercising intact fingers because of the enslaving phenomena.

REFERENCES

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2. Beekhuizen KS, *J Neurol Phys Ther*: **29**: 157-162, 2005