

# THE EFFECT OF AGING ON MULTI-FINGER FORCE PRODUCTION

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## INTRODUCTION

The reduction of muscular strength and power associated with aging is rather well documented. Some studies focussed on the hand, one of our most common effector, using hand-gripping tasks. In particular changes in motor unit properties have been documented with selective atrophy of high threshold motor units (Owing, Grabiner, 1998). However, these tasks do not provide information about changes in finger coordination with aging.

In a previous series of studies (Li et al., 1998), we investigated finger coordination during maximal force production (MVC) by a set of finger. Those studies demonstrated the following features. MVC by several fingers acting in parallel was shown to be smaller than the sum of MVCs of these fingers in single-finger force production tasks (force deficit). Force production by one finger was accompanied by involuntary force production by other fingers (enslaving). The total force was shared in a specific manner (sharing pattern).

The goal of this study was to provide a preliminary set of data to address changes in finger coordination associated with aging as reflected in such indices as force deficit, enslaving, and sharing pattern.

## METHOD

Two groups of subjects were tested. The first group (OLD) included five elderly subjects ( $72 \pm 2.4$  years). The second group (CONT) was composed of 14 subjects ( $28.2$

$\pm 8.7$  years). In all trials, subjects were asked to press as strongly as possible (MVC) with a particular finger combination: either with one finger (index, middle, ring or little finger), or with all four fingers. These five combinations were proposed in a pseudo-randomized sequence. During single-finger tasks, subjects were asked to pay no attention to forces produced by the others fingers (slave fingers). Two sites of force generation were used 1) at the distal phalanges, and 2) at the proximal phalanges. Based on the anatomy of the tendon attachment, we assumed that in the first case, extrinsic and intrinsic muscles were activated, while in the second case, only intrinsic muscles produced force. T-tests were used to compare indices as MVC, enslaving, and force deficit. MANOVAs were used to compare force sharing patterns.

## RESULTS

1) As expected, MVCs were lower for the OLD group. MVCs with four fingers dropped by 28% at the distal site (115 versus 83 N), and by 51% at the proximal site (163 versus 83 N).

2) The comparison between 4-fingers and 1-finger exercises, revealed larger force deficit for elderly subjects. At the distal site, force deficit was 9% for the CONT group and 21% for the OLD group. At the proximal site, these values were respectively 11% and 26% for the CONT and OLD groups.

3) Because of the significant differences in the MVCs between the groups, enslaving was expressed in terms of the average

percentage of MVC exhibited by each slave finger. No difference in enslaving was found at the distal site (17%). By contrast at the proximal site, enslaving was smaller for the elderly subjects (17% versus 23%).

4) During the four-finger tasks, the sharing pattern of the total force across fingers was the same for both groups, independently of the site of force production (I=29%, M=32%, R=22%, L=17%).

## DISCUSSION

The data suggest several effects of aging on finger coordination.

The disproportional reduction in MVC produced by the OLD group at the proximal phalanges suggests that aging may be associated with selective impairment of intrinsic hand muscles. Note that a change in the properties of some of the elements involved in a multi-finger synergy is likely to lead to a rearrangement of the whole synergy. In particular, some of the changes seen in the elderly are similar to those seen in healthy subjects under finger fatigue (Danion et al., 2000) that have been shown to lead to a central reorganization.

The increased force deficit in the OLD group also suggests an involvement of a central reorganization. The force deficit may be viewed as consequence of an inability to recruit certain high-threshold motor units. However, these motor units are the ones to show atrophy with age (Owing, Grabiner, 1998). Therefore, an increase in force deficit is probably a reflection of a central reorganization.

The smaller indices of enslaving in the OLD group are unexpected. They mean that elderly subjects had better control over individual finger forces, in contrast to the

predominant view that aging is associated with a degradation in different aspects of motor performance.

The same sharing pattern in the two groups suggest that despite the many peripheral and central changes associated with aging, the central nervous system is still able to preserve the basic multi-finger synergy that defines force distribution among fingers.

## SUMMARY

We investigated the effect of aging on finger coordination during maximal force production by one or several fingers acting in parallel. The results suggest 1) a greater impairment of the intrinsic hand muscles, and 2) a lower ability to recruit the maximum force of individual finger during multi-finger tasks. Despite these changes, the synergy that defines force distribution among fingers is preserved.

## REFERENCES

- Danion, F. et al. (2000). *J. Physiology (Lond)*, in press.
- Owing T.M., Grabiner, M.D. (1998). *J. Gerontol. A Biol. Sci. & Med. Sci*, **53**, B425-429.
- Li, Z.M., et al. (1998). *Exp. Brain Research*, **119**, 276-286.

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