THE STRENGTH-DEXTERITY TEST AS A MEASURE OF PINCH PERFORMANCE IN THE ABLE AND IMPAIRED HAND

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INTRODUCTION

We currently lack quantitative and objective measures of key and opposition pinch to effectively diagnose pinch impairment and compare treatment outcomes. To address this need, we developed and tested a method to evaluate the dynamic interaction between pinch force magnitude (**strength**) and directional accuracy (**dexterity**) the fundamental building blocks of effective manipulation *(Murray et al., 1994; Valero-Cuevas et al., 1998)*. The strength-dexterity (S-D) test is based on the ability to use pinch to fully compress springs with different requirements of strength (i.e., force to fully compress) and dexterity (i.e., proportional to slenderness (free length/diameter); more slender springs require greater directional accuracy not to buckle). The propensity to buckle is *independent* of spring rate, hence strength requirement *(Samónov, 1980)*. This study evaluates the repeatability of the S-D test and compares S-D scores from able and impaired adults.

METHODS

Every possible combination of strength and dexterity is a point on the S-D plane defined by two orthogonal axes representing strength and dexterity. We approximated the S-D plane by 87 springs, each 25-mm long, with 14 strength (range: 1 to 92 N) and 8 dexterity (A through H, range: 0.28 to 2.33 m/m) levels (see Figure 1). All subjects

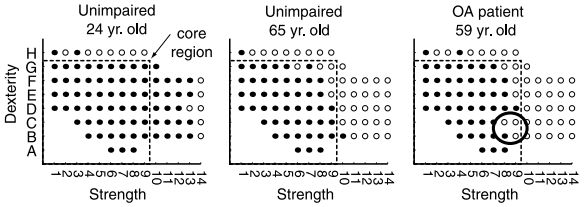
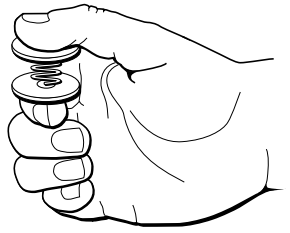


Figure 1. S-D tests in opposition pinch by representative females of each group. Fully compressed springs are shown as filled circles. The dashed line shows the core region young adults could achieve, the oval highlights the OA patient's deficit compared to the older adult.

read, understood and signed the consent form approved by University Committee on Human Subjects at Cornell University. We asked each subject to attempt to fully compress all springs using key (Figure 2) and opposition (pads of thumb against pads of index and middle finger) pinch in random order, providing a 5 s rest between spring presentations. The strength and dexterity scores are the summation of the strength and dexterity levels, respectively, of all springs the person could compress fully. Of the 29 participants, 17 were unimpaired adults under the age of 40 yrs. (**group A**, mean age 22– 5 yrs, range 18 - 39), 7 were unimpaired adults over the age of 40 yrs. (**group B**, mean age 54– 13 yrs, range 40 -78), and 5 were older adults with thumb osteoarthritis

Figure 2. Compressing a spring with key pinch.



(**group OA**, mean age 65– 12 yrs, range 50 - 79). To test repeatability, we tested 14 group A subjects on two different days.

RESULTS

The test-retest analysis yielded a subject-wise repeatability ≥ 0.94 for all springs.

Every subject of group A could compress all springs in the core region shown in Figure 1.

In contrast, most of group B and all OA participants could not compress all springs in the core region. S-D scores for the core region are numerically lowest for the OA group and highest for group A (Table 1).

DISCUSSION

The essence of dexterous manipulation, particularly for lightweight objects, is the ability to simultaneously and dynamically modulate the magnitude and direction of force at the fingertips. In contrast to pinch meters (the most common test of pinch function) that measure maximal force against a stable object, the S-D test assesses the sensorimotor ability to dynamically produce well directed forces of submaximal magnitude. As such, it is a reproducible measure that is descriptive of the ability to manipulate lightweight objects essential to our activities of daily living.

The core S-D region found in this study describes the expected minimum pinch performance of unimpaired young adults.

We see two important trends in the B and OA groups, to be tested statistically when we sample more subjects. First, not all older adults achieved this minimum S-D score, suggesting that continuing this work may improve our ability to quantify the sensorimotor degeneration known to occur in old age *(Falconer et al., 1991)*, for which no simple clinical tests exist.

And second, because OA patients achieved consistently lower S-D scores than older adults, the S-D test can quantify the pinch impairment known to occur in OA, and help assess pinch impairment and compare treatment outcomes.

A limitation of this study is that a more precise S-D kit is needed. Note, for example, the discontinuity in the H row of the OA patient, which may be due to variable tolerances of commercial springs. Custom springs will be built to remove this possible experimental artifact.

With further work, the strength-dexterity test can become a simple, reliable clinical tool to quantify pinch impairment and to compare treatment outcomes.

	Key Pinch				Opposition pinch			
	dexterity score, m/m		force score, N		dexterity score, m/m		force score, N	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A	37.3	0	716.4	0	37.33	0	716.4	0
B	35.8	1.7	658.5	61.1	36.06	2.1	665.71	53.5
OA	28.6	13.4	500.0	280.8	27.78	12.1	448.3	250.9

Table 1. Average S-D scores for core region

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