RELATIONSHIP BETWEEN CLINICAL AND BIOMECHANICAL MEASURES OF HAND FUNCTION

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INTRODUCTION

Impaired upper extremity and hand function are major debilitating factors for the performance of activities of daily living (ADL) in aging and disabled populations. Typically, function has been evaluated clinically using standardized performance tests such as the Box and Block test (BBT) and coin rotation tasks. While informative, these tests measure hand function in global terms and in isolation of functional motor performance. In general, clinical tests of manual function are more concerned with movement quantity as opposed to movement quality. Conversely, the precise control of muscle forces is an elementary component of skilled movement production and its quantitative assessment provides insight into the control and coordination of voluntary hand movements. Further, Kilbreath et al. revealed that approximately 54% of ADL's involve bimanual tasks [1]. Thus, a more specific and functionally relevant assessment protocol may be needed.

The purpose of this study is to compare performance on the clinical unimanual tasks that are commonly used to assess manual dexterity to a more objective, functionally relevant and quantifiable bimanual dexterity paradigm. The paradigm was designed to replicate the performance of many ADLs (i.e. opening a container or buttoning a shirt) in which one hand functions to stabilize the object while the other hand performs some manipulation of the object. The bimanual dexterity system is equipped with force\torque transducers to measure grasping forces produced by both hands simultaneously.

METHODS

Eighteen right-handed (RH), 12 left-handed (LH), and seven ambidextrous (AM) healthy college students, between ages of 18 to 30, participated in this study. Handedness was assessed by a modified version of the Edinburgh Handedness Inventory [2]. Participants were asked to be seated comfortably and to perform both unimanual and bimanual movement tasks. The unimanual tasks consisted of the BBT, a coin rotation task (turning a nickel with thumb, forefinger, and middle), and a lock rotation task (turning a combination lock with a precision grip). Participants were instructed to complete each task as fast as possible and performed the tasks using both their dominant and non dominant hand. The dependent measure for the BBT was the number of the blocks transferred in one minute. For coin rotation and lock rotation tests, the time that participants needed to complete 10 turns was recorded. The average of all three trials was used for statistical analysis.

In the bimanual task, participants were asked to simultaneously grasp the two stacked transducers (Figure 1) with a precision grip, and to separate the top transducer from the bottom one, with one hand on the top and the other hand on the bottom. The transducers were connected via an 8-Newton electromagnetic force. Participants performed this task four times with their dominant hand serving as the manipulating hand (upper transducer) and four trials with their non-dominant hand serving as the manipulating limb. Order of the four trial block was randomized across hands. Movement time (MT), the time interval between the onset of grip force and the time at which the separation of devices occurs, was measured and used with unimanual task scores for statistical analysis.

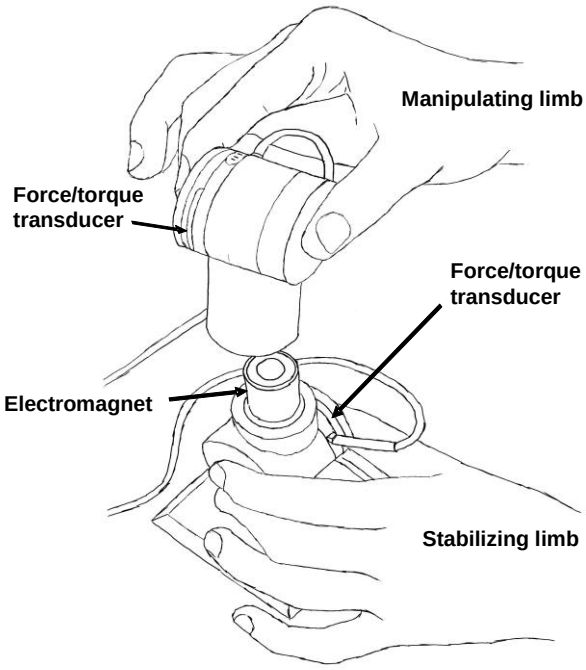

Figure 1: Illustration of bimanual dexterity device. The lower limb serves to stabilize the object while the upper limb acts to manipulate and separate the two objects.

RESULTS AND DISSCUSSION

Performance on the clinical tests and the functional bimanual task were related. Specifically, performance of coin rotation tasks with the dominant hand was significantly related to movement time when the dominant hand was on the upper transducer (RH: r=.515, p=.01, LH: r=.477, p=.04). Although the scores of BBT were not related to MT in both groups, MT and the scores of lock rotation task when using the dominant hand were found to be significantly correlated (RH: r=.395, p=.05, LH: r=.624, p=.01). However, when participants used their non-dominant hand, none of unimanual task scores were significantly correlated with bimanual task performance. The descriptive statistics are listed in Table 1.

Our results indicate that bimanual task performance (MT) clearly correlated well with commonly used functional unimanual tasks when participants used their dominant hand to lift the upper transducer. This suggests the bimanual task measurement used here appears to be valid for estimating upper extremity function. However, careful consideration seems to be required since grip strength is also likely to influence our outcome measures. In this study, we also measured participants' grip strength and compared it to the upper device MT. We found strong correlation between them when participants used their dominant hand to grasp the upper device (RH: r=-.536, p=.01, LH: r=-.548, p=.03). Since the magnet resistance was applied to the transducers in the bimanual task measurement, participants needed to generate enough grip force to lift the upper transducer. Therefore, we need to consider both force modulation and manual dexterity when we study bimanual task performance. Since our bimanual task performance measure correlated with standardized performance tests, and since the force transducers we used can quantify kinematic and kinetic data simultaneously, it has potential to be a more comprehensive measure of manual dexterity than current clinical measures of dexterity.

REFERENCES

1. Kilbreath SL, et al. *Aust J Physiother* **51(2)**, 119-122, 2005
2. Oldfield RC *Neuropsychologia*, **9**, 97-113, 1971

Table 1: Means (SD) of unimanual dexterity scores and bimanual task performance

	BBT (# blocks)		**Coin Rotation (s)**		**Lock Rotation (s)**		**Movement Time (s)**	
	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-dominant
Right-handed	69.6 (9.0)	65.0 (7.9)	6.8(1.2)	8.2(2.3)	9.7(1.9)	11.2 (2.8)	0.69 (0.33)	0.71(0.35)
Left-handed	67.2 (7.1)	66.0(7.2)	7.6(1.5)	8.6(3.5)	12.9(3.1)	12.1(2.2)	0.79 (0.39)	0.79(0.35)