Rehabilitation Engineering Laboratory Hand Function Test for Functional Electrical Stimulation Assisted Grasping

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Introduction

Currently, an assessment that can thoroughly evaluate unilateral gross motor function of the hand does not exist. Particularly, this type of test would be beneficial to assess improvements in hand function that are the result of application of a neuroprosthesis for grasping. Typically, neuroprostheses for grasping are used as prosthetic systems with complete C5 to C7 spinal cord injured (SCI) patients. As well, more recently, neuroprostheses are used as devices that can assist hemiplegic and incomplete SCI patients in restoring voluntary grasping function. An assessment is needed that can be used as an evaluation tool to assess improvements of gross motor function of the hand, particularly lateral pinch, pulp pinch and palmar grasps. The field of occupational therapy can be instrumental in the implementation of a hand assessment dedicated to evaluating improvements in function after neuroprosthesis training.

Thus far, two attempts were made to develop such an assessment. Stroh Wuolle, et al \cite{1} proposed the Hand Grasp and Release Test, which consists of six different objects to be grasped and released by patients. Five out of the six test objects can be easily acquired, such as a pop can and videotape, since they are objects commonly used in activities of daily living (ADL). The remaining test object, which is used to simulate the use of a fork, is a non-standardized object. The “fork” in this test is difficult to manufacture and cannot be readily replicated by other researchers. One of the main weaknesses of this test is that two out of the six tests are not discriminative with respect to this group of patients. Patients were able to achieve high scores with and without using a neuroprosthesis. In addition, this test was used on a small sample size, five subjects, and its inter-rater and intra-rater reliability have not been fully established. The test proposed by Popovic et al \cite{2} appears to be a better test since it assesses the subjects’ ability to manipulate objects, which are naturally used in ADL. However, this test was not properly documented, with various manuscripts citing use of different test items. This inconsistency, along with limited information about its validity and reliability, limit its practical use.

In this article, a new assessment tool is proposed that can accurately capture improvements in the gross motor function of the unilateral grasp. The test evaluates lateral pinch, pulp pinch and palmar grasps.

Materials and Methods

The assessment consists of two sets of tests, object manipulation and strength tests.

1.1 Object manipulation test

The object manipulation test was developed to evaluate how the subject uses his/her palmar and lateral/pulp pinch grasps when the hand is in pronated, neutral and supinated position (see Figure 1). To test the palmar grasp, the subject is presented with the following five items: mug, book, pop can, isosceles triangular sponge and mobile phone. To test the lateral or pulp pinch grasp, the subject is presented with the following five items: paper sheet, zip-lock-bag filed with five golf balls, die, credit card and pencil. The objects are placed on a desk 20-30 cm in front of the subject, one after another, in a pre-determined order. The subject is expected to pick up an object, lifting it in front of the chest, and move the object from a pronated to a neutral position, followed by a supinated position. In each position the subject is expected to hold the object for 20-30 s. If in any of these three
positions the subject is unable to hold the object, he/she receives 0 points for that position. If the subject holds the object for a short period of time (e.g., 2 to 10 s) and eventually drops the object, then the subject is awarded 1 point. Finally, if the subject is able to hold the object for 20-30 s, he/she receives 2 points for that particular hand position. For the ‘mug’ task, since holding the mug in a supinated position has no practical value, the subject is not asked to perform this task. Similarly, the subject is not asked to perform supination with the zip-lock-bag task. Therefore, the maximum scores representing palmar grasp ability in pronation, neutral and supination are 10, 10 and 8, respectively. Similarly, the maximum scores representing lateral or pulp pinch grasp ability for pronation, neutral and supination are 10, 10 and 8, respectively. The minimum score is 0 for all six cases. The following is the order in which the tasks are presented to subjects:

MUG [palmar grasp]: Object description: A standard mug; a subject can grasp the mug by putting at least three fingers out of four (preferably all four) into the handle. The mug should be filled with wax to simulate normal mug load, if it was filled with water. Wax was chosen to provide safety in the event the mug drops or slips out of the patient’s hand. Total weight of the mug, with wax, is approximately 350-400 g. Rational: Drinking out of a mug/cup is a typical ADL task.

PAPER SHEET [pulp/lateral pinch grasp]: Object description: A single sheet of paper A4 or Letter size. Rational: Picking up a sheet of paper is a component of a typical ADL task.

BOOK [palmar grasp]: Object description: A standard paperback “Penguin” book with 150-200 pages; smooth covers should be used. The total weight of the book should be around 0.2-0.3 kg. Rational: Picking up a book is a component of a typical ADL task.

ZIP LOCK BAG [pulp/lateral pinch grasp]: Object description: A zip lock bag filled with 5 golf balls. The bag has to be closed at the top. The dimensions of the bag are approximately: 170 mm x 200 mm. The balls should be allowed to move freely in the bag. The total weight of the bag, with balls, should be around 200 g. Rational: Picking up a bag filled with popcorn/muffin/beans/peas is a typical ADL task.

CAN OF COKE [palmar grasp]: Object description: A full can of Coke 0.333 l should be used. Rational: Picking up/drinking from a can of Coke is a typical ADL task.

DIE [pulp/lateral pinch grasp]: Object description: A standard die for gambling should be used. Rational: Picking up a die/sugar cube is a component of a typical ADL task.

SPONGE [palmar grasp]: Object description: A sponge that has an isosceles triangular shape, dimensions: height 40 cm, base 20 cm and thickness 10 cm). Rational: Picking up an object which is not firm and is deforming when force is applied to it (e.g., pillows and clothing) is a component of a typical ADL task.

CREDIT CARD [pulp/lateral pinch grasp]: Object description: A standard credit card should be used. Rational: Picking up/using a credit card is a typical ADL task.

MOBILE PHONE [palmar grasp]: Object description: A standard mobile phone should be used. Rational: Picking up/holding a cellular phone is a typical ADL task.

PENCIL [pulp/lateral pinch grasp]: Object description: A standard HB pencil should be used. Rational: Picking up a pencil is a component of a typical ADL task.

1.2 Strength test
Strength of the grasps is tested using the following four tools: nine rectangular blocks, instrumented cylinder, credit card attached to a dynamometer and wooden bar.
RECTANGULAR WOODEN BLOCKS [palmar grasp] Objects description: Nine rectangular wooden blocks should be used, with approximate dimensions of 40 mm x 40 mm x 120 mm. Three blocks should weigh 100 g each, the other three should weigh 200 g each, and the remaining three should weigh 300 g each. For each group of three blocks with the same weight: one should have a slippery surface made of overhead protecting covers; the second should have a polished wooden surface; and the third should have a non-slippery surface made of Dycem. Rational: This test is aimed at assessing how the subject manipulates objects identical in size, but having different surfaces and weights.

Test: Each of the nine blocks should be placed on a desk, 20-30 cm in front of the subject, so that the blocks are standing vertically. The subject should try to grasp each of the blocks and hold onto them longer than 20-30 s. The subject will be marked using a scale of 0, 1, and 2 - where 0 indicates the subject cannot hold a block, 1 indicates the subject can hold the block for few seconds and then drops it, and 2 indicates that the subject can hold the block for more than 20-30 s.

INSTRUMENTED CYLINDER [palmar grasp] Object description: A cylinder with a diameter of 30 mm, the surface made of polished wood, and having a torque meter attached to it. The torque meter can record torques in the range of 0-5 Nm with a resolution of 0.05 Nm. Rational: This test is aimed at assessing the grasping torque of the subject’s palmar grasp. This information is essential in assessing if the subject can grasp and use objects such as a knife, toothbrush, hairbrush and shaver without allowing the object the slip while they are applied in ADL.

Test: The subject should hold the cylinder using a palmar grasp. The person administering the test should apply torque to the instrument until the cylinder starts sliding in the hand. Record the torque needed to rotate the cylinder.

CREDIT CARD & DYNAMOMETER [pulp/lateral pinch grasp] Object description: A credit card attached to a dynamometer that has a range of measurable forces from 0-50 N with a resolution of 0.5 N. Rational: This test is aimed at assessing the grasping force of the subject’s pulp or lateral pinch grasp.

Test: The subject should hold the credit card using a pulp or lateral pinch grasp. The person administering the test should apply force to the instrument until the card starts sliding out of the hand. Record the force needed to pull the card.

WOODEN BAR [palmar grasp] Object description: A wooden bar that has an elliptic cross section with diameters of 35 mm and 40 mm, a length of 800 m and the weight being 600 g. It should be engraved with horizontal lines, 10 mm apart. The line in the middle should be marked as 0, with the neighbouring lines marked as 1, and all other lines to the left and right labelled with numbers from 2 to 30 in ascending order. Rational: This test is aimed at assessing the subject’s palmar grasp in handling eccentric loads. This is important when a subject handles objects such as a hammer, jug, frying pan or fishing rod.

Test: The subject should hold the bar in the middle of the handle using a palmar grasp (at the 0 line, in the middle of the palm). The person administering the test should slowly push the bar in one direction until the eccentricity of the load causes the grip to release the bar. Record the line on the bar with the highest number before the bar stops being horizontal and becomes inclined. The same test is done by pushing the bar in the opposite direction.

Results

The REL Hand Function Test for Functional Electrical Stimulation Assisted Grasping is presently being evaluated for its discriminative properties in assessing functional improvements in grasping abilities. A research study is currently being conducted, using the REL Hand Function Test with individuals with hemiplegia,
resulting from stroke. Within this study, the REL Hand Function Test is undergoing inter-rater reliability testing, as well as being compared with another well-established functional hand assessment to determine its sensitivity in monitoring change of grasping function.

Discussion

The use of functional hand assessments is an integral component in the realm of hand therapy, within the larger field of occupational therapy (OT). Considering the REL Hand Function Test has been designed for use within OT, its applicability needs to be compared with another well-established hand assessment. The Jebsen Test of Hand Function and the Test Evaluant les Membres Superieurs des Personnes Agees (TEMPA) are two assessments being considered for comparison with the REL Hand Function Test in measuring change of functional, grasping ability.

References:


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Figure 1: The REL Hand Function Test: Itemized objects used in the test