

TORONTO REHABILITATION INSTITUTE HAND FUNCTION TEST: UNILATERAL GROSS MOTOR FUNCTION ASSESSMENT

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Abstract

Functional electrical stimulation therapy (FES) can restore voluntary reaching and grasping function in patients who have sustained a C5 to C7 spinal cord injury (SCI) or who have had a stroke. FES therapy, as well as conventional occupational therapy (OT), focuses primarily on restoring lateral pinch, pulp pinch, and palmar grasp -- all are required to perform activities of daily living (ADLs). The Toronto Rehabilitation Institute Hand Function Test (TRI-HFT) is the first assessment tool designed to evaluate unilateral gross motor function of the hand; specifically, lateral pinch, pulp pinch, and palmar grasp. The purpose of this paper was to validate the TRI-HFT as a reliable assessment instrument of unilateral gross motor function of the hand. This study was performed in two parts. First the study was designed to determine the reliability of the TRI-HFT. Second, the study examined the sensitivity of the TRI-HFT. The TRI-HFT was found to have high intra- and inter-rater (observer) reliability. The TRI-HFT was capable of measuring a 20% improvement in unilateral gross motor function following six weeks of FES therapy combined with or without occupational therapy. The results of this study clearly established the TRI-HFT to be a valid assessment instrument of unilateral gross motor function of the hand.

1 INTRODUCTION

One of the primary goals of FES therapy (alone or combined with conventional occupational therapy (OT)) is to restore lateral and pulp pinch, and palmar grasps for hemiplegic stroke and SCI (C5 to C7) patients^{1,2}. No standardized assessment tool currently exists to specifically evaluate unilateral gross motor function of the hand with respect to lateral pinch, pulp pinch and palmar grasp. Several assessment tools have been described in the literature however they either have not been validated or require specific instrumented objects with design specifications which are difficult to replicate³⁻¹⁰. The TRI-HFT is unique. It is the first assessment tool to measure unilateral gross motor function focusing specifically on lateral pinch, pulp pinch and palmar grasp. It is also the first functional assessment tool to utilize standardized everyday objects that are readily available worldwide. The patient may or may not use a neuroprosthesis for grasping to assist them in manipulating the objects during the TRI-HFT. Thus the TRI-HFT can be used to assess the

effectiveness or progress of: 1) conventional occupational therapies or physiotherapies, 2) neuroprosthesis for grasping as an orthosis in ADL, or 3) neuroprosthesis for grasping applied as a therapy to restore voluntary grasping function (FES therapy).

2 METHODS

2.1 Objective

The purpose of this paper was to establish the reliability and validity of the TRI-HFT as an evaluation tool of unilateral gross motor function of the hand for SCI or hemiplegic stroke patients.

2.2 Study Design

Content Validation. The content validity of the TRI-HFT was established through discussions with two third-party OT experts in the field of SCI rehabilitation, who critically reviewed the items in the test. Their expert opinions confirmed the coverage and comprehensiveness of the test items.

The Toronto Rehabilitation Institute Hand Function Test (TRI-HFT). The TRI-HFT consists of two parts. The two parts of the TRI-HFT should be administered in sequential order (part one followed by part two). The first part of the test assesses the patient's ability to manipulate objects using 1) lateral and pulp pinch and 2) palmar grasp. All of the objects may be encountered in their daily lives (Figure 1).

1. Objects: an ordinal scale representing the lifting of several ordinary objects using different hand positions. (Figure 1, objects 1-10)

The second part of the test measures the strength of their lateral or pulp pinch and palmar grasp.

2. Blocks: an ordinal scale representing the lifting of wooden blocks with varying degrees of slipperiness and weight. (Figure 1, object 11)
3. Cylinder: a numerical measurement of the maximum torque generated by a palmar grip on a 3 cm diameter cylinder. (Figure 1, object 12)

4. Credit card: a numerical measurement of the maximum force resisted by a pinch grasp on a credit card. (Figure 1, object 13)
5. Wooden bar: a numerical measurement of the eccentric load that can be held in a pronated palmar grip measured using an axe handle of approximately 3 cm diameter and 50 cm length. (Figure 1, object 14)

Scoring: Part 1: Object Manipulation: Test objects 1 to 10 (Figure 1) were placed sequentially on a desk 20-30 cm in front of the participant. The participant was requested to pick up the objects, lift them in front of his/her chest and move the objects from supination to neutral and then to pronation position. In each position, the participant was told to hold the object for 20-30 s. If the participant was unable to hold the object in any of these three positions, then he/she received 0 points for that position. The participant received 1 point if they could hold the object for a short period of time (2-10s) and then eventually drop it. Finally, participants received 2 points if he/she was able to hold the object for 11-30 s in the intended hand position.

Part II: Test objects 11 to 14 were used to measure torque generated by the palmar grasp, force produced by the pinch grasp and exocentric load that the palmar grasp can sustain, respectively. This part of the test was not validated because the test results are objective.

The TRI-HFT should be administered by a hand or upper extremity specialist (physiotherapist or OT). The entire evaluation takes approximately 35 minutes to complete.

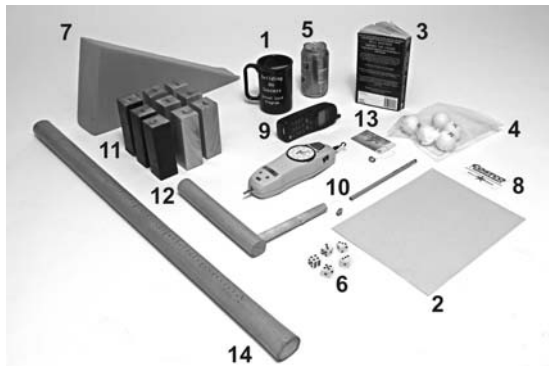


Figure 1: The Toronto Rehabilitation Institute Hand Function Test: Itemized objects used in the test

Participants and Observers. The gross motor hand function of 10 participants (4 female and 8 male) with a C5 to C7 SCI and 10 participants (5 female and 5 male) with hemiplegia following a stroke was evaluated using the TRI-HFT. The mean age was 46 years (range=19-74, SD=17.6). Each patient evaluation was videotaped, labelled according to the "Guidelines for Data and Privacy Protection at the Rehabilitation Engineering Laboratory" and encrypted. A single DVD containing the 20 encrypted videoclips was created for distribution to the observers.

Twelve observers with diverse clinical experience reviewed the videoclips of 20 patients. The observers included 3 physicians, 3 physiotherapists, 2 occupational therapists, 3 mechanical engineers, and 1 research assistant (BSc). They were divided into

four groups according to their clinical experience/training with upper extremity therapy: Expert, Physicians, Physiotherapists, and Inexperienced. The observers were blinded to the participant's diagnosis and rehabilitation treatment history. Each observer independently evaluated each of the video clips twice. The second assessment was performed at least 7 days following completion of the first evaluation.

Inter-Rater Reliability. To test for inter-rater reliability and to determine if clinical experience would influence the outcome of the TRI-HFT, scores were correlated between individuals of the same experience group and between individuals of different experience groups. A Spearman's correlation coefficient was calculated to analyse the data.

Intra-Rater Reliability. To test for intra-rater reliability, individual scores from the first and second assessments were compared. A Spearman's correlation coefficient was calculated to analyse the data.

Sensitivity. A separate pilot study was undertaken to determine the sensitivity of the TRI-HFT. The TRI-HFT was administered to 9 hemiplegic stroke participants (5 males and 4 females) prior to commencement of Functional Electrical Stimulation (FES) and OT or OT alone to establish a baseline score. The mean age was 62 years (range=32-80, SD=16.3). After six weeks of therapy, unilateral gross motor function was evaluated using the TRI-HFT again. Clinically significant improvement in upper extremity function was defined as a minimum increase of 12 points (out of 56) or 20% improvement from the baseline score (Part I: object manipulation). This value was determined by the expert judgment of the two OTs. The Wilcoxon Signed Ranks Test was calculated to analyse the data and determine how sensitive to change the TRI-HFT is.

3 RESULTS

Content Validity. Four main themes were identified: 1) assessment guidelines; 2) scoring criteria; 3) internal consistency; and 4) activity-based tasks. Strict administration and scoring guidelines are required for standardization of the TRI-HFT. To improve the sensitivity and prevent floor and ceiling effects, the experts proposed a scoring scale with more gradations than the existing 3-point ordinal scale. Potential variability in shoulder and trunk instability may influence the scores. The use of ADLs to assess hand function significantly enriches the value of the results obtained from the TRI-HFT.

Inter-Rater Reliability. The Spearman correlation coefficient assessing inter-rater reliability was 1.0 ($p < 0.01$). All of the participants received the same scores from the 12 observers. The experience of the observer had no effect on the scores.

Intra-Rater Reliability. The Spearman correlation coefficient assessing intra-rater reliability was 1.0 ($p < 0.01$). All of the participants received the same scores from the 12 observers on two separate occasions. The experience of the observer had no effect on the scores.

Sensitivity. Nine participants with baseline TRI-HFT scores of zero were treated with FES plus/minus OT for six weeks. At the end of the 6 weeks, 6 of the participants attained a significant improvement (20%) in their TRI-HFT scores. Three participants had no improvement in their TRI-HFT scores (remained at zero). The Wilcoxon Signed Ranks Test resulted in $z = 2.201$, $p = 0.028$.

4 DISCUSSION

This study validates the TRI-HFT as a simple but sensitive assessment tool to evaluate unilateral gross motor hand function of patients who have sustained a C5 to C7 spinal cord injury (SCI) or who have had a stroke with residual hemiplegia. It is the first assessment tool designed specifically to focus on their ability to: 1) manipulate universally available standardized objects encountered in our daily lives; and 2) perform lateral pinch, pulp pinch and palmar grasp. The TRI-HFT also objectively evaluates lateral pinch, pulp pinch and palmar grasp strength.

The TRI-HFT is very easy to use to evaluate hand function. There was no difference in participant scores between assessments of a single observer nor did the level of experience influence the score recorded for a participant. All observers received only minimal training (written instructions) prior to performing the assessments.

The sensitivity of the TRI-HFT was examined in a separate pilot study. Clinically significant improvement/change was conservatively defined as a minimal increase of 12 points from baseline or a 20% improvement in the baseline score. Despite the small number of participants in this pilot study, clinically significant improvement was detected in 6 of the 9 participants following six weeks of FES therapy with or without OT. The criterion used in this study represent only an "educated and conservative opinion". Further testing is required with a larger sample size.

5 CONCLUSIONS

The TRI-HFT is a valid assessment instrument of unilateral gross motor function of the hand for patients with a C5-C7 SCI or who have had a stroke. It can reliably be used to assess the participants' response to rehabilitation therapy (FES and/or occupational therapy).

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