ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2013;94:451-8

ORIGINAL ARTICLE

Establishment of a Proper Manual Tactile Test for Hands With Sensory Deficits

Hsiu-Yun Hsu, MS,[a,b] Li-Chieh Kuo, PhD,[c] I-Ming Jou, MD, PhD,[d] Shu-Min Chen, MD,[b] Haw-Yen Chiu, MD, PhD,[e] Fong-Chin Su, PhD[a,f]

From the [a]Department of Biomedical Engineering, National Cheng Kung University, Tainan; [b]Department of Physical Medicine and Rehabilitation, National Cheng Kung University Hospital, College of Medicine, Tainan; [c]Departments of Occupational Therapy and [d]Orthopedics, [e]Section of Plastic Surgery, Department of Surgery, and [f]Medical Device Innovation Center, National Cheng Kung University, Tainan, Taiwan.

Abstract

Objectives: To (1) develop the Manual Tactile Test (MTT) for evaluating the hand perception to distinguish objects' characteristics; (2) establish the reliability and validity of the MTT for patients with carpal tunnel syndrome (CTS); and (3) integrate a normative database into the test.

Design: Cohort and case-control studies.

Setting: Hospital and local community.

Participants: Participants included patients with CTS (n=70) and healthy volunteers (n=125). Twenty young volunteers were enrolled to evaluate the reliability of the test. Seventy patients with CTS and 70 age- and sex-matched controls were recruited to establish the discriminate validity and receiver operating characteristic (ROC) curves for the MTT. A normative database was constructed from 125 healthy, right-handed participants.

Interventions: Not applicable.

Main Outcome Measures: The MTT was designed to discriminate the characteristics of the objects' weight (barognosis test), texture (roughness differentiation test), and shape (stereognosis test) via active hand exploration. The times required discriminating the characteristics of objects and the accuracy of judgment were recorded and analyzed.

Results: High Cronbach alpha values (.83−.91) and small coefficient of variation (.10−.16) values showed that the MTT is a reliable testing tool. The results significantly discriminated the patients from the control group ($P<.001$). The sensitivity and specificity were .64 to .81 and .73 to .76, respectively, for the 3 subtests. The ROC curve area for the 3 subtests ranged from .70 to .84. The results of the MTT obtained from 125 healthy subjects showed that age significantly affects hand perceptive function ($P<.001$).

Conclusions: The MTT is a reliable, accurate, and valid tool for determining the impairment of manual touch sensibility for CTS and can help clinicians understand age-related degradation in sensorimotor control of the hand in the elderly population.

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Hands serve both executive and perceptual functions based on the biomechanical advantages of opposable thumbs and rich mechanoreceptors in the skin of grasping digits.[1] However, to produce smooth and timely manipulation of objects, both the internal presentation of previous experience and momentary peripheral sensory information participate in the control strategy.[2] Thus, sensory function plays a critical role in the functional use of hands. Accordingly, it is important for clinicians to assess sensory function in an objective, accurate, and timely manner for patients with potential sensory disturbances. Two-point discrimination and Semmes-Weinstein monofilament (SWM) tests are usually applied for the purpose of quantifying the perception of protective and discriminative sensation in the hands of patients with sensory deficits. When executing these sensory tests, a stimulus is applied to the cutaneous surface; however, the stimulus input that is given is highly subjective.[3] Sensory input applied in a passive manner

Supported by the National Science Council, Taiwan (grant no. NSC 97-2314-B-006-047-MY2).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.

Clinical Trial Registration No.: ER-98-195.

0003-9993/13/$36 - see front matter © 2013 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2012.07.024

without permitting voluntary hand movement is called a passive touch.[4] It has been reported that the transmission of tactile input is diminished and that sensory data cannot be efficiently acquired under the passive touch condition.[5,6]

In contrast, an active touch incorporates information of proprioceptive and tactile inputs through intended movements.[6] People use a 2-stage sequence, a general grasping stage and a more precise exploratory process, to extract the underlying properties of objects more efficiently.[7,8] That is, the hand uses motor capabilities to greatly extend its tactile resolution.[9] A previous experimental result indicated that people could classify the shapes of objects correctly with active exploration but could not properly identify them through passive touch.[10,11] Similarly, tactile texture perception has been found to be seriously degraded under passive touch conditions.[12] Thus, integrated impulses transmitted synchronously from proprioceptors and mechanoreceptors by an active touch can help us to recognize properties of objects or can enable us to handle surfaces more clearly.[6]

Sensory deficiencies in a hand usually result in clumsy manual performance even if the motor components of the hand remain intact, such as in the case of patients with peripheral nerve injury or carpal tunnel syndrome (CTS).[13,14] Nevertheless, the results of traditional sensory tests for an injured hand correspond little with the hand function.[15,16] Therefore, exploratory procedures have been strongly recommended as the key component by which to assess hand sensibility with objectiveness. Most notably, the concept of "sensory grip" proposed by Moberg[16] should therefore be joined to the processes of sensibility tests for the purpose of linking between the testing results and functional capability for the hand. Recently, several experiments have indicated that the tactile quality heavily relies on gathering information from active exploration using the hand.[17-20] Accordingly, tests for actively sensing the properties of objects should be developed for assessment of functional sensibility.[20-22]

The hand detects the physical properties of objects and then adjusts the proper muscle force exertion and joint angles accordingly when executing a task.[2,23,24] However, to our knowledge, there is not a test that can allow patients with sensory deficits to completely detect the weight, geometry, and texture of objects. High reliability and validity have been reported in a Hand Active Sensation Test,[22] but the spatial properties of objects have not been evaluated. Besides, the exploratory sense of moving/passive touch pressure for stroke patients developed by Dannenbaum et al[21] showed low testing reliability, and the responsiveness has yet to be determined. To design an appropriate method for detecting the exploratory perception objectively, comprehensive information about properties such as the weight, texture, and shape of an object should be devised in the test. In addition, there are significant differences in the predictions of hand function among traditional sensibility tests,[25] and there is a gap between the understanding of impairments in regard to a specific sensibility and the identification of complex sensory loss. Therefore, this study developed a new set of related tests called the Manual Tactile Test (MTT). The first aim of this study was to develop and investigate the reliability and validity of the MTT, a sensory test through manual exploration, for determining sensory deficiency in patients with established CTS. To understand the accuracy of the new evaluation tool, the second aim was to construct the sensitivity and specificity of the test. In addition, a normative database was installed into the MTT to provide additional reference values corresponding to sensory impairment.

List of abbreviations:

AUC	area under the curve
CTS	carpal tunnel syndrome
CV	coefficient of variation
M2PD	moving 2-point discrimination
MTT	Manual Tactile Test
ROC	receiver operating characteristic
S2PD	static 2-point discrimination
SWM	Semmes-Weinstein monofilament

Methods

General design

This study was designed to investigate the reliability, validity, and accuracy of a newly developed test, the MTT, and its clinical applications with patients with CTS. Three subsets of the MTT (barognosis, roughness differentiation, and stereognosis test) were performed. Accuracy in judgment and the times required to complete each test were recorded to assess the tactile function via an exploratory procedure.

Participants

Study participants included 70 clinically defined patients with CTS and 125 healthy subjects. The reliability of the MTT was determined using 20 healthy, young volunteers (10 men, 10 women; mean age ± SD, 22.74±1.06y). To understand the discriminant validity of the MTT for CTS and healthy subjects, the diagnosis for the patients was based on clinical symptoms, sensibility tests, and nerve conduction studies. The inclusion criteria for the patient groups were as follows: (1) significant CTS symptoms (eg, paresthesia and numbness sensation in the thumb and fingers); (2) distal median nerve neuropathy as proved using the nerve conduction velocity; (3) good-to-normal grade of muscle power of the abductor pollicis brevis muscle; and (4) right-handed. Patients with diabetic mellitus, other neurologic deficits, previous hand injuries, and cognitive deficits were excluded from the sample. Seventy-nine patients with CTS were referred by rehabilitation medicine and orthopedic outpatient clinics from a university hospital in southern Taiwan over a period of 6 months. However, 9 patients who had a history of previous strokes, hand trauma, and diabetes mellitus were excluded from the study. Therefore, 70 patients (54 women, 16 men) having the classic picture of predominantly sensory CTS in 119 hands (64 dominant and 55 nondominant hands) met the inclusion criteria and were recruited in the study. The mean age ± SD was 53.84±10.82 years (range, 31−77y). Seventy control subjects from the local community matched for age, sex, and handedness were recruited in the control group. The subjects in the control group had no sensory disturbance or any neurologic disorder affecting the hands.

To develop the normative database of the MTT, 125 healthy subjects were recruited. The results of the MTT were analyzed for 3 age groups: 18 to 35 years, 36 to 55 years, and older than 55 years. The youngest group (18−35y; mean age ± SD, 25.6±4.3y) consisted of 41 young, healthy adults, of whom 20 were women and 21 were men. The middle group (36−55y; mean age ± SD, 45.4±5.9y) consisted of 42 healthy volunteers, of whom 22 were women and 20 were men. The oldest group (mean age ± SD, 66.0±6.9y) consisted of 42 healthy participants, of whom 20 were women and 22 were men.