Functional Hand Evaluations: A Review

Scott D. McPhee

Key Words: dexterity evaluation • hand evaluation • prehension

Describing hand prehension patterns in the context of functional hand evaluations may not provide the therapist or surgeon with an accurate portrayal of a patient's capabilities. Although dexterity involves both static and dynamic components of hand usage, most descriptions of prehension patterns study the static phase alone. Hand use is a function of anatomic integrity, mobility, strength, sensation, coordination, age, sex, mental status, disease or trauma, and the condition of other proximal extremity joints (shoulder, elbow, wrist). In this study, various descriptions of hand prehension patterns were reviewed and 11 functional hand evaluations were analyzed. The purpose was to see if the descriptions and the evaluations have common elements. The conclusions are that there are no common elements, that no hand function evaluation is appropriate for all types of patients, and that such evaluations should consist of tasks representative of everyday functional activities.

At the time of this study, Major Scott D. McPhee, MS, OTR, was Chief Occupational Therapist, Ireland Army Community Hospital, Fort Knox, Kentucky. He currently is a student at the U.S. Army Command and General Staff College, Fort Leavenworth, Kansas 66027.

Humans have been unable to build a machine more perfectly balanced and coordinated than the human hand. The thumb's ability to swing widely from the palm lends to the hand's extraordinary versatility. Furthermore, the ability to oppose each of the four digits with an equal force provides a structural basis for coordination. Add sensibility, and the stage is set for dexterity. Analysis of function for this marvelous machine must involve a three-dimensional assessment.

In a sense, the wrist is simply a mechanical device for contributing to the usefulness of the hand, for it increases the variety of positions in which the hand may be used. In fact, all of the joints of the upper extremity may be viewed as servants of the hand.

The therapist with any amount of experience in hand rehabilitation knows that patients with adequate strength may not be coordinated enough to accomplish many simple tasks, that patients with adequate coordination may not have the strength to accomplish simple tasks, and that patients with poor range of motion and severe deformities may have both the strength and coordination to accomplish a multitude of tasks. The function of the hand intricately involves motion, strength, dexterity, and motivation. Given this complexity, it seems appropriate to ask, Does a consensus on a definition of hand function exist?

Descriptions of Hand Functions

Many investigators have characterized the hand's functional positions involved in manipulating objects. In 1942, McBride described a method of classifying hand function for use in disability evaluations in workmen's compensation cases. He suggested functional descriptions according to the parts of the hand involved (grasping with the hand as a whole, grasping with the thumb and fingers, and combined use of the palm and the digits).

Griffiths, in 1943, categorized the various hand prehension patterns as cylindrical grip, ball grip, ring grip, pincer grip, and pliers grip.

Tylor and Schwartz (1955) expanded the classifications of hand function by adding the terms fist grasp, cylindrical grasp, book grasp, lateral prehension, palmar prehension, and tip prehension.

Napier drew attention to hand function by introducing the terms power grip, hook grip, precision grip, and combination grip in 1956. He based his classification on the anatomy and physiology of the hand. Although thought to be a classic description of hand function, his description did not directly address the dynamic relationship of object and movement. Landsmeer (1962) discussed this point and suggested adding a dynamic perspective by changing the term precision grip to precision handling.
Kapandji (1970) described a method of defining prehension patterns in terms of the digital segments involved during manipulation. The terms he described were palmar prehension, prehension by digito-palmar opposition, prehension by subtermino-lateral opposition, prehension by subtermino opposition, prehension by termino opposition, and prehension between two sides of the fingers.

Skerik, Weiss, and Flatt suggested in 1971 that the terms power grip, lateral grip, book grip, tip pinch, and palmar pinch could adequately describe hand manipulation patterns.

More recently, Kamakura, Matsuo, Ishii, Mitsu­boshi, and Miura (1980) conducted an extensive study of static hand prehension patterns in nondisabled subjects. They were able to identify 14 basic patterns: 5 patterns of power grip (involving wide areas of the hand, palm, and volar surfaces of the digits with the ulnar digits flexed more than the radial digits), 4 patterns of intermediate grip (in which the palm of the hand is not in contact with the object and contact areas include the radial aspects of the index and middle digits), 4 patterns of prehension grip (in which objects are held between the volar aspects of the digits and the pulp of the thumb with mild flexion of the digits), and 1 prehension pattern that does not involve the thumb.

The main problem with these descriptions of hand function is that they are based on a generally static interpretation of object manipulation. They are descriptions of the end product once the object is firmly secured in position. The dynamic quality of function is glaringly absent.

Attempts to detail the dynamic components associated with object and hand have generated considerable data. Sollerman and Sperling (1976) developed a coding system to describe prehension patterns associated with object manipulation. This system uses 23 code designations for variables associated with hand grasp patterns. It addresses five basic areas: which fingers and other parts of the hand directly participate in the grasp pattern, the relative position of the fingers, the position of each finger joint, which contact surfaces of the fingers and palm are pressed against the object, and the relationship between the longitudinal axis of the object and the hand. This system addresses the dynamic relationship of motion and object handling and greatly enhances the accuracy of defining prehension patterns as they are associated with hand use. Although this method successfully measures complex variations of object manipulation, the data generated are useful mainly in research.

Bendz (1974) stated that the description of grip should include the various phases of the grip procedure: the initial opening phase, purposeful closing and stabilizing phases, and the terminal opening phase. Static descriptions of hand function alone do not provide the information necessary for the hand therapist and surgeon to determine the patient’s status. Nor can the evaluation of hand function be limited to the prehension patterns described in the literature. A hand function test should provide pertinent information about the performance of the hand as it accomplishes a task. The test need not necessarily include either anatomical or physiological measurements (i.e., strength, range of motion, and sensation) because these are more appropriately measured by other clinical examinations.

Sollerman and Sperling (1978) reported that all activities of the human hand can be divided into eight main types of hand prehension patterns. The prehension patterns and their estimated percentage of use in activities of daily living are as follows:

<table>
<thead>
<tr>
<th>Prehension Pattern</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp pinch</td>
<td>20%</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td>20%</td>
</tr>
<tr>
<td>Five-finger pinch</td>
<td>15%</td>
</tr>
<tr>
<td>Diagonal volar grip</td>
<td>15%</td>
</tr>
<tr>
<td>Transverse volar grip</td>
<td>14%</td>
</tr>
<tr>
<td>Tripod pinch</td>
<td>10%</td>
</tr>
<tr>
<td>Spherical volar grip</td>
<td>4%</td>
</tr>
<tr>
<td>Extension grip</td>
<td>2%</td>
</tr>
</tbody>
</table>

A competent hand function test should include a measurement of the quality of selected basic hand grasp patterns both static and dynamic, that is, it should provide a comprehensive assessment of the overall function of the hand as it accomplishes adequate object manipulation. Because a truly useful assessment determines how the hand functions in daily life situations, a hand function test should comprise tasks involved in activities of daily living and should use prehension patterns to the approximate extent that these patterns are used in daily life.

Hand Function Tests

Many hand function tests have appeared in the literature; however, this review was limited to 11 tests published since 1965.

Carroll (1965) attempted to determine which functions of the upper extremity are impaired by injury or disease and how these functions change with advancing disease or surgery or other treatment. He stated that the measurement of individual muscles and joint range of motion can provide only a partial glimpse of a patient’s ability to use the hands. Effective substitution patterns and patient motivation cause muscle tests and range of motion tests to become inaccurate sources of information. Carroll defined several upper extremity functions (grasp, grip, pinch, arm extension, supination, pronation, forward flexion, and shoulder abduction) but did not measure...
any of these activities in isolation because he sought to measure the total functioning of the upper extremity. Employment of this test, Quantitative Test of Upper Extremity Function, requires fabrication of a special wooden apparatus. The 33 subtests consist, in part, of moving objects to a shelf, placing objects over a peg, writing, placing the hand to the mouth and head, and pouring water from a pitcher into a glass. Each subtest is scored subjectively on a 4-point scale:

0 = Unable to perform the task
1 = Completes task partially
2 = Completes test but is slow and clumsy
3 = Performs the task normally

To demonstrate the efficacy of this evaluative system, Carroll tested 79 patients in 11 different diagnostic categories. Unfortunately, although he reported on interrater reliability and test-retest reliability, he did not provide statistical analyses to support his conclusions that the “test has sufficient reliability and consistency to measure improvement or deterioration in function when performed serially” (p. 491).

Jebesen, Taylor, Trieschman, Trotter, and Howard published the Hand Function Test in 1969. They stressed that hand function is not an isolated function but is dependent on the proximal portion of the upper extremity to position the hand. They also suggested that mental status and other factors contribute to an individual’s ability to perform. With this in mind, the authors detailed five goals for their test: to provide objective measurements of standardized tasks with norms for comparison, to assess patterns of hand function commonly used in activities of daily living, to document a continuum of ability within each category of hand function tested, to be easy to administer in a short period of time, and to use testing equipment and materials that are readily available. The test measures hand function through a series of seven subtests that represent a broad range of tasks (feeding, writing, turning pages, moving large and small objects). Scores are based on the number of seconds it takes to complete each task. The authors explained all procedures and instructions for administration.

Jebesen et al. tested a nondisabled sample of 360 adults ranging in age from 20 to 94 years. Fourteen two-way analyses of variance were completed to determine the effects of age and sex on each subtest. The analyses showed that scores differed by sex and that the time needed to complete each subtest increased with age. The authors therefore reported their results by sex and age (two groupings: 20–59 and 60–94 years). A test-retest study of 26 patients from various diagnostic categories showed that each subtest score was fairly reliable over time ($p < .01$).

The purpose of MacBain’s (1970) Hand Function Test for the rheumatoid hand was to establish an objective method of recording the functional results of hand surgery (i.e., metacarpophalangeal arthroplasties). The 11 subtests measure strength of grip and pinch (using a modified blood pressure cuff), hook grasp (lifting a bucket filled with weights), and functional tasks. The functional tasks are measured by the time it takes to complete each task and are further categorized as involving applied strength (cutting with a knife, pouring water into a cup) and precision strength (buttoning, picking up and holding coins). The author tested approximately 100 nonarthritis subjects to establish her grading system, and based on her observations, she divided scores into four categories (normal, good, fair, and poor) and determined how much of a change in subtest scores constituted a significant change. She then, over a period of several weeks, tested 10 new subjects who had either operated or nonoperated rheumatoid hands. Although she reported no statistical results, MacBain concluded that her assessment tool is valid because there was no dramatic change in scores over time. She recommended that test administrators should note any influences on performance such as pain, anxiety, and attitude toward surgery.

Clawson, Souter, Carthum, and Hymen (1971) published another functional assessment for the rheumatoid hand. The authors’ four objectives were to establish a reliable test, to establish an index of hand function, to determine if the type and rapidity of functional impairment could be predicted with reasonable accuracy, and to study the natural history of changes in hand function for rheumatoid patients and how function could be changed through operative treatment. The test’s five subtests measure power, architectural stability, and unilateral–bilateral coordination. Strength readings and time to complete certain tasks form the basis for scoring. Grip and pinch are measured with a modified blood pressure cuff, architectural stability is measured with a specially designed instrument, and coordination is measured with a knife-and-fork test and a bunton test. Clawson et al. used a total of 210 hands to establish an index of hand function. This index is represented by a 100-point scale, and each subtest has a maximum value of 20 points. To test the sensitivity of the test, over a period of 1 year the authors retested 25 hands that had undergone one or more operative procedures. Statistical analysis showed a significant improvement of function, and the authors concluded that their index provides reliable assessment of functional performance.

Potvin et al. (1972) developed the Simulated Activities of Daily Living Examination to evaluate individuals presenting a broad variety of neuromuscular disorders. This test comprises 19 subtests, including the following: standing, walking, putting on...
a shirt, buttoning, zipping, putting on gloves, dialing a phone, tying a bow, manipulating safety pins, manipulating coins, threading a needle, unrolling a Band-Aid, squeezing toothpaste, and using a knife and fork. The authors described in detail the equipment and mode of administration for each subtest. A stopwatch is used to record the number of seconds it takes to complete each subtest.

In order to standardize the data, Potvin et al. studied 40 nondisabled young adults. The authors also measured this test's application to disabled persons by comparing 10 patients with Parkinson's disease with 10 matched control subjects and comparing 10 patients with multiple sclerosis with 10 matched control subjects. To test the reliability of the measurement procedures, Potvin et al. asked 18 of the control subjects to return 1 month later for reevaluation. The correlation coefficients for 13 of the 15 subtests were low \((r < .70)\), and the authors suggested inaccurate timing of tasks as a possible cause for the low correlations. The authors did not intend this test to provide objective measures of improvement (in strength, reaction time, coordination, mental status, sensation, etc.) but to indicate a person's ability to carry out functional tasks of daily living.

The purpose of the Smith Hand Function Test (Smith, 1973) is to provide objective indications of a patient's progress, determine the efficacy of drugs in the treatment of various diseases, and establish hand function norms according to age, sex, and dominance. Smith developed 13 subtests to provide measurements in grip strength and unilateral-bilateral hand dexterity. The test is divided into four subsections: Section A, Unilateral Grasp/Release Tasks; Section B, Activities of Daily Living; Section C, Writing Sample; and Section D, Grip Strength (Dynamometer Reading). Smith suggested that test administrators also make subjective comments evaluating shoulder and elbow range of motion. She advised that using her test as a predictor of performance of activities of daily living would be inappropriate because the assessment does not cover finger, wrist, elbow, shoulder, trunk, and hip motions. Except for the measurement of grip strength, all subtest results are recorded in the number of seconds it takes to complete each task. Smith used a population of 91 nonhandicapped males and females (ages 21 to 62 years) to establish a standardized baseline for comparison. Her analysis consisted of calculating means, standard deviations, and ranges and comparing performance of right and left hands and of males and females. She concluded by listing parameters she did not measure: eye-hand coordination, shoulder and elbow range of motion, types of grasps used, visual deficits, and fatigability or reaction time.

Bell, Jurek, and Wilson (1976) designed the Physical Capacity Evaluation to test hand skill. They tested the evaluation on 50 nondisabled subjects in order to standardize the results. The test consists of nine subtests measuring grasp-release patterns, pinch and prehension patterns, and strength (dynamometer readings). Time in seconds is the critical measure. The authors used means and standard deviations for comparisons but, unfortunately, presented no tables or raw data for review. Also, they did not justify the use of the plus/minus one standard deviation as an acceptable range in which to complete each task and did not complete reliability or validity testing. The authors concluded that this test could be used as an indicator of the need for therapeutic intervention and as a predictor for success in therapy, but their conclusions are based on a small sample size and the authors' subjective observations.

In 1978, Walker, Davidson, and Erkman measured various functions of the hand in a study of the metacarpophalangeal joints in patients with rheumatoid arthritis and compared the results with performance of a nonarthritic population. This hand function test has five subtests covering the areas of movement (active and passive range of motion), strength (pulp, lateral, and chuck pinch; extensor strength; grip strength; radial and ulnar forces), and manipulation (holding, placing, and twisting motions). Results are recorded in static strength measurements and the time it takes to complete manipulative tasks. Walker et al. used a uniquely designed apparatus that is not easily reproduced. Assessing only the dominant hands, the authors studied 145 nonhandicapped adults to obtain the standardized data and also tested 30 adults with arthritis. Comparing the scores for control subjects with scores for the arthritic population, Walker et al. present grip and pinch strength ranges for both men and women. The authors concluded that a functional examination of the hand is important for pre- and postsurgical evaluations.

Wilson's (1984) Functional Test was designed to measure upper extremity functional capability after a cerebral vascular accident. The test provides the therapist with a grading system that can assist in justifying the implementation of a treatment program. This assessment takes approximately 30 minutes, but there is no time limit for any of the 17 subtasks. The patient receives a plus for accomplishing a task and a minus if he or she cannot accomplish a task. Wilson reported high correlations with objective measures such as range of motion, sensation, and spasticity, but did not substantiate this claim with statistical data.

Mathiowetz, Volland, Kashman, and Weber (1985) developed normative data for the adult use of the Box and Block Test. This test involves moving 2.5 cm (1 inch) square blocks from one side of a box to the other side, going over a partition. The authors...
obtained their normative data from 628 volunteers (310 men and 318 women), scoring them on the number of blocks they manipulated during a 1-minute time period. Mathiowetz, Volland, et al. presented their results by age (5-year categories with approximately 26 subjects per group) and by sex. Reliability testing using the test-retest format over a 6-month period resulted in very high rho coefficients (.937 and .976). Also, the reported interrater reliability was high (for the left hand, \( r = .999 \); for the right hand, \( r = 1.00 \)). The authors admitted that the Box and Block Test is a general test of gross manual dexterity and does not measure coordination and fine dexterous movements. They recommended using this test to evaluate patients suspected of having impairments in manual dexterity.

Mathiowetz, Weber, Kashman, and Volland (1985) recently reexamined the Nine Hole Peg Test of finger dexterity, presenting a more extensive analysis of the test than did Kelloe, Frost, Silberberg, Iversen, & Cummings (1971). Mathiowetz, Weber, et al. sought to establish standardized administration procedures, to analyze reliability and validity, and to establish norms for clinical interpretation of the test. To assess reliability and validity, they tested 26 occupational therapy students, finding a very high interrater reliability (for the right hand, \( r = .97 \); for the left hand, \( r = .99 \)) and only moderate test-retest reliability (for the right hand, \( r = .69 \); for the left hand, \( r = .43 \)). To determine concurrent validity, the authors used the Purdue Pegboard for a comparison parameter. They reported a significant inverse relationship (for the right hand, \( r = .61 \); for the left hand, \( r = .53 \)). Unfortunately, the small sample size and use of subjects knowledgeable about hand function render the reliability and validity results questionable.

Mathiowetz, Weber, et al. reported normative data from 618 subjects (310 men and 308 women) ranging in age from 20 to 94 years. For men and for women, they reported mean time (in seconds) to complete the test, standard deviation, standard error, and high and low scores. The authors also reported results by age, using 5-year age groupings. They emphasized the cautious use of this test and further suggested it be used as a quick screening tool for finger dexterity. If deficits in performance are found, further testing is indicated because reliance on the Nine Hole Peg Test alone is inappropriate. Finally, in the authors' conclusion, they addressed the need to study the relationship between tests of dexterity, tests of hand function, and performance of functional activity.

**Discussion**

Table 1 summarizes some characteristics of the functional hand evaluations reviewed here. As it shows, 91% of the tests use unilateral tasks whereas only 55% use bilateral activities. Five tests use unilateral activities exclusively, and one test uses bilateral activities exclusively. Only 27% of the tests use subjective grading systems, and of these only Carroll's (1965) and Wilson's (1984) tests use the subjective reporting system exclusively. In all, 82% of the tests provide objective measures. For five tests, authors have reported on reliability testing. Mathiowetz, Volland et al. (1985) had the largest sample size (628 subjects).

What these tests really measure can be answered by closely examining their measurement parameters. Most (82%) use time as the critical measure of function, a fact that is understandable because time is the easiest parameter to manipulate statistically. But time is not an accurate description of hand function. Hand use cannot be described simply by measuring speed. Using speed as the critical measure raises the question of how to deal with the reaction time of the person who starts and stops the stopwatch. Potvin et al. (1972) addressed this problem as a possible reason for the variation of retest results. For example, when a task takes only 2 seconds to complete and the timer has a reaction time of up to 0.10 seconds, a 10% variation in measured scores is possible. This variation can affect results considerably.

The described hand function tests are considerably varied and lack a clear consensus for a definition.

**Table 1**

**Summary of Functional Hand Evaluations Reviewed**

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Number of Subtests</th>
<th>Functional Tasks</th>
<th>Measurement</th>
<th>Sample Size</th>
<th>Reliability Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unilateral</td>
<td>Bilateral</td>
<td>Objective</td>
<td>Subjective</td>
</tr>
<tr>
<td>Carroll (1965)</td>
<td>33</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>79</td>
</tr>
<tr>
<td>Jobson et al. (1969)</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MacBain (1970)</td>
<td>11</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>100</td>
</tr>
<tr>
<td>Clawson et al. (1971)</td>
<td>5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>210</td>
</tr>
<tr>
<td>Potvin et al. (1972)</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smith (1973)</td>
<td>13</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>91</td>
</tr>
<tr>
<td>Bell et al. (1976)</td>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>50</td>
</tr>
<tr>
<td>Walker et al. (1978)</td>
<td>5</td>
<td>X</td>
<td></td>
<td>X</td>
<td>145</td>
</tr>
<tr>
<td>Wilson (1984)</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Mathiowetz, Volland et al. (1985)</td>
<td>1</td>
<td>X</td>
<td>X</td>
<td></td>
<td>628</td>
</tr>
<tr>
<td>Mathiowetz, Weber, et al. (1985)</td>
<td>1</td>
<td>X</td>
<td>X</td>
<td></td>
<td>618</td>
</tr>
</tbody>
</table>
The clinician should not use one particular type of test exclusively to evaluate all disabilities, but should study and analyze each test to understand its appropriate use. Clinicians should have a number of functional hand tests at their disposal.

The ability of a patient to use his or her hands effectively in everyday activities is dependent on anatomical integrity, mobility, muscle strength, sensation, coordination, and motivation. It is also influenced by age, sex, mental status, and disease processes affecting not only the hands but also other body systems. Although knowledge of these variables may allow for some reasonable predictions about hand function, only rarely can definite statements be made. For this reason, hand function tests should use tasks representative of everyday functional activities. More work needs to be done describing the dynamic qualities of hand prehension. This information then needs to be developed into a hand function test that can be wide-ranging in purpose and broad in scope.

References


