Hand Function Evaluation: A Factor Analysis Study

Tal Jarus, Ruth Poremba

Key Words: assessment process, occupational therapy • hand injuries • motor skills

The purpose of this study was to investigate hand function evaluations. Factor analysis with varimax rotation was used to assess the fundamental characteristics of the items included in the Jebsen Hand Function Test and the Smith Hand Function Evaluation. The study sample consisted of 144 subjects without disabilities and 22 subjects with Colles fracture. Results suggest a four factor solution: Factor I—pinch movement; Factor II—grasp; Factor III—target accuracy; and Factor IV—activities of daily living. These categories differentiated the subjects without Colles fracture from the subjects with Colles fracture. A hand function evaluation consisting of these four factors would be useful. Such an evaluation that can be used for current clinical purposes is provided.

Hand function evaluations are an important element of the assessment process in physical rehabilitation settings (Jones, 1989). However, there is no consensus among professionals that any one evaluation adequately measures hand function or has an accepted definition of hand function (Jones, 1989; McPhee, 1987).

The value of a hand evaluation depends on how it incorporates the contributing factors of hand function, such as pinch, grasp, precision accuracy, coordination, and activities of daily living (ADL) tasks. Napier (1956) classified hand function according to different grips and to whether power or prehension was a component in manipulation. Landsmeer (1962) expanded on Napier's classification by changing the term precision grip to precision handling. Though it may not seem a major expansion, this change in terms emphasizes the dynamic quality of hand function. Other authors have contributed to this original classification. Skerik, Weiss, and Flatt (1971) confined hand manipulation patterns to power grip, lateral grip, hook grip, tip pinch, and palmar pinch. Kamakura, Matsu, Ishii, Mitsu, and Miura (1980) identified 14 basic patterns of static hand prehension. However, all these classifications presented hand function as static, concentrating only on the stage when the object is firmly secured in position. As McPhee (1987) pointed out, the dynamic quality of function is ignored. Static descriptions of hand function provide valuable information, but do not provide adequate data by which to determine a patient's status and progress. The dynamic qualities of how the hand manipulates objects and performs in tasks of daily living are integral to any hand function assessment (McPhee, 1987).

There are numerous hand function evaluations to choose from, such as range of motion (ROM) testing, the Nine Hole Peg Test (Mathiowetz, Weber, Kashman, & Volland, 1985), and the Simulated Activities of Daily Living Examination (Potvin et al., 1972). However, no evaluation covers all aspects of hand function, such as anatomical integrity, mobility, muscle strength, sensation, grasp patterns, precision and accuracy, coordination and dexterity, unilateral and bilateral tasks, ADL tasks, and motivation (McPhee, 1987).

In deciding which hand function test to include in the present study, we deemed the following factors important: types of subtests, standardization of the evaluation, quickness and reliability in administration, and ease in fabrication. Two tests qualified—the Jebsen Hand Function Test (JHFT) (Jebsen, Taylor, Trieschmann, Trottier, & Howard, 1969) and the Smith Hand Function Evaluation (SHFE) (Smith, 1973). We believed that these two tests were representative of hand function but certainly not ideal.

The JHFT is one of the few hand function tests that has established norms (Jebsen et al., 1969; Rider & Linden, 1988). It is easily available and can be administered...
in a short time. The JHFT consists of seven subtests that are representative of a wide variety of daily tasks: writing, turning over cards, manipulating small objects, simulated eating, stacking checkers, manipulating large light objects, and manipulating large heavy objects. However, quality of prehension patterns is not assessed; rather, the evaluator concentrates on the speed with which a person completes the task. Additionally, the test does not assess hook and power grasp patterns and does not represent the area of ADL well. The JHFT does attempt to distinguish differences in hand function with light or heavy objects, and each subtest evaluates the dominant and nondominant hand separately. However, there is no subtest of bilateral integration and coordination.

Like the JHFT, the SHFE (Smith, 1973) can be administered in a short time. It consists of 13 subtests that evaluate fundamental grips and prehension, as well as bilateral coordination and dexterity, through tasks of daily living. However, the SHFE does not include tasks that combine strength with pinch or grasp or grasp patterns such as hook and tip. Neither the SHFE nor the JHFT acknowledges the qualitative aspects of hand function. Rather, speed (the number of seconds it takes to complete a task) defines the degree of function.

We believed that a combined version of these two tests might result in a more comprehensive hand function evaluation. A factor analysis was used for that purpose. Factor analysis is a widely used statistical tool by which one is able to condense an evaluation with multiple factors into a workable number of factors or variables.

Method

Subjects

One hundred and forty-four volunteers without disabilities and 21 volunteers with Colles fracture composed the study sample. In the nondisabled sample, there were 70 (48.6%) men and 74 (51.4%) women, aged 20 to 80 years, with an average age of 49.49 years (SD = 18.09). Ninety-two percent of the subjects without Colles fracture were right-handed; 8% were left-handed. In the sample with Colles fracture, there were 3 (14.3%) men and 18 (85.7%) women, aged 24 to 82 years, with an average age of 63.9 years (SD = 15.05). Ninety-one percent of them were right-handed; 9% were left-handed.

Instruments

The JHFT (Jebson et al., 1969), and the SHFE (Smith, 1973) were used to test hand manipulation abilities. The tests were translated into Hebrew for this study. The seven subtests of the JHFT (writing, turning over cards, manipulating small objects, simulated eating, stacking checkers, manipulating large light objects, and manipulating large heavy objects) were administered to the nondominant hand first and then to the dominant hand. Time to complete the subtest was measured.

Norms for subjects without disabilities aged 20 to 94 years are available for each subtest according to age and gender (Jebson et al., 1969). A test-retest reliability study of 26 patients representing 11 different diagnostic groups showed a rho coefficient ranging from .60 to .90, which indicated that the test was fairly reliable over time. The test was also able to discriminate various degrees of disability of the subjects in the study, which indicates that it is valid (Jebson et al., 1969).

The SHFE consists of 13 subtests on four categories of function: Unilateral grasp release tasks; ADL, which include bilateral tasks; writing sample; and grip strength. Smith (1973) obtained norms for 91 subjects without disabilities, ranging in age from 21 to 62 years, grouped in the subtests by gender and right and left hand scores. No reliability or validity tests were performed. Smith substantiated the test's content validity, recommending only minor changes. For example, because grip strength does not relate to the ability to perform activities requiring coordinated movements, she recommended that this section be omitted. She also recommended that, in the safety pin subtest in the ADL section, the number of safety pins be increased to four and the sizes varied, to allow the tester to obtain an accurate score (the number of seconds it takes to complete a task) and to add a component of graded difficulty to the task. When the JHFT and the SHFE are combined there are 34 subtests (testing both the dominant and the nondominant hand in the appropriate subtests).

Procedure

All subjects were tested on the two tests, which took approximately 1 hr. Time to perform each of the 34 subtests was recorded. The order of administering the two tests was counterbalanced among all subjects. Subjects were given numbers; all even-numbered subjects started with the JHFT and all odd-numbered subjects started with the SHFE. A demographic questionnaire was also administered.

Data Analysis

Data were analyzed in three stages. In stage 1, a factor analysis with orthogonal varimax rotation was used to reduce the 34 subtests into a smaller number of derived factors while still retaining most of the legitimate information. Highly correlated subtests were grouped into factors. Performance on the subtests in each factor is theoretically considered the consequence of a single underlying hand function. Distinct factors were derived, although the factors were not unrelated. Therefore, factor analysis was used to test the validity of theoretical ideas about subtest types in order to decide which sub...
tests should be included in a comprehensive hand function test (Munro, Visintainer, & Page, 1986).

In stage 2, reliability coefficient tests, specifically Cronbach’s alpha model, were applied to each factor to determine its reliability and exclude subtests that proved unreliable. In stage 3, to test the ability of the comprehensive hand function test to predict hand function, factor scores were computed for each subject and the t-test was used to compare the group mean of the sample without Colles fracture with the group mean of the sample with Colles fracture.

**Results**

The results of the factor analysis indicated that four factors had accounted for at least 5% of the variance (a criterion suggested as appropriate [Munro et al., 1986]), and these described the structure of the evaluation variables. The results of the varimax rotated factor loadings for the four factors, including the items with factor loadings above .40, a loading considered substantial (Kerlinger, 1973; Munro et al., 1986), are shown in Table 1. The four factors identified are pinch, grasp, target accuracy, and ADL.

The results of the reliability coefficient tests performed on the four identified factors was the exclusion of 18 subtests, which in turn reduced the reliability of each factor (see Table 2).

The four items in Factor I represent activities that require pinch movement, which involves the thumb and the index finger when manipulating small to mediumsized objects. The four items in Factor II represent grasp. These items require gross movements of the whole hand to grasp and manipulate large objects. All six items of Factor III correspond to activities that require precision manipulation. All objects grasped and manipulated involve accuracy and placement. For example, the checkers had to be stacked one on top of the other. The two items in Factor IV simulate activities of daily living, specifically the handling of objects during performance of daily personal care.

Four factor scores were computed for each of the 144 subjects without Colles fracture and the 21 subjects with Colles fracture. With the mean factor scores of both groups a multivariate analysis of variance (MANOVA) was performed. The MANOVA for the four factor scores revealed a significant difference between the two groups (Wilks’s exact $F[4,147] = 11.78, p < .001$). A subsequent univariate ANOVA performed on the four factor scores revealed significant differences between the two groups on all factor scores. The subjects without Colles fracture

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Factor Solution After Reliability Tests</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor</th>
<th>Items</th>
<th>Alpha Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinch</td>
<td>Large pegs&lt;sup&gt;a&lt;/sup&gt; (D)</td>
<td>.9313</td>
</tr>
<tr>
<td></td>
<td>Large pegs&lt;sup&gt;a&lt;/sup&gt; (N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small pegs&lt;sup&gt;a&lt;/sup&gt; (D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small pegs&lt;sup&gt;a&lt;/sup&gt; (N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety pin&lt;sup&gt;g&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tie knot&lt;sup&gt;h&lt;/sup&gt;</td>
<td>.9635</td>
</tr>
<tr>
<td></td>
<td>Large light object&lt;sup&gt;b&lt;/sup&gt; (D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large light object&lt;sup&gt;b&lt;/sup&gt; (N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large light object&lt;sup&gt;b&lt;/sup&gt; (D)</td>
<td></td>
</tr>
<tr>
<td>Target accuracy</td>
<td>Checkers&lt;sup&gt;b&lt;/sup&gt; (D)</td>
<td>.8540</td>
</tr>
<tr>
<td></td>
<td>Checkers&lt;sup&gt;b&lt;/sup&gt; (N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocks&lt;sup&gt;a&lt;/sup&gt; (D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocks&lt;sup&gt;a&lt;/sup&gt; (D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nails&lt;sup&gt;a&lt;/sup&gt; (D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nails&lt;sup&gt;a&lt;/sup&gt; (N)</td>
<td></td>
</tr>
<tr>
<td>Activities of daily living</td>
<td>Eating&lt;sup&gt;a&lt;/sup&gt; (D)</td>
<td>.8099</td>
</tr>
<tr>
<td></td>
<td>Eating&lt;sup&gt;a&lt;/sup&gt; (N)</td>
<td></td>
</tr>
</tbody>
</table>

Note: D = Dominant, N = Non-dominant
<sup>a</sup>Items from Smith Hand Function Evaluation  
<sup>b</sup>Items from Jethon Hand Function Test

---

The American Journal of Occupational Therapy

441

performed faster than the subjects with Colles fracture, indicating that the four factors can distinguish one population from the other (see Table 3).

Discussion

The identification of four factors in this factor analysis of the Jebsen Hand Function Test and the Smith Hand Function Evaluation suggests that the two tests contain four theoretical categories of hand function: pinch, grasp, movements for accuracy, and ADL. These categories partly fulfill the theoretical definition of hand function, as stated in the literature (Jones, 1989; McPhee, 1987).

Despite our desire to derive a comprehensive hand evaluation, not all the types of manipulation patterns are represented in the four categories. For example, neither hook nor power grip (Skerik et al., 1971) is represented, and quality of movement, or the static aspect of prehension, cannot be evaluated by this comprehensive test. These weaknesses are similar to those found by McPhee (1987) in established hand evaluations. A reliable way of evaluating the quality of movement in these four categories still needs to be established.

The domain of hand function dealing with ROM, strength, and anatomical integrity is not directly evaluated in task-oriented evaluations, yet we believe that it is reflected in the outcome of the present evaluation. Another weakness of the comprehensive evaluation is that the label given to the last factor might seem misleading. Although eating is an activity of daily living, it is questionable whether the eating subtest is representative of all elements involved within this domain, such as toileting, dressing, and grooming. A careful look at Table 1 indicates that some of the ADL subtests, such as buttoning, shoe lacing, and buckling, had a low loading on the fourth factor. This suggests that further research is necessary to establish a proper ADL factor. Similar limitations apply to the other three factor categories.

This study was designed to identify problems in existing hand function evaluation tools and their redundant commonalities. We believe that the combination of factors from the Jebsen and Smith tests results in a more suitable tool. The combination provides a possible solution to the identified problem that current hand function evaluations do not cover all aspects of hand function. The new evaluation is made up of four factors (pinch, grasp, target accuracy, and ADL) that are not found in the Jebsen or Smith tests alone.

An advantage of this comprehensive hand function test is the validity and reliability test computations reported, that is, the factor analysis, reliability tests, and comparison between the two samples. However, further tests of reliability and validity are needed, such as interrater or test-retest reliability. Additionally, the suitability of the test for populations other than those with Colles fracture needs study.

An additional advantage of the comprehensive hand function evaluation is that it permits one to calculate a factor score for each of the theoretical categories, thus a single score can be assigned for each dimension of hand function. Therefore, the scores in this test can be used for statistical analysis of the changes in the underlying dimensions of interest. This will help to monitor the patient's progress in specific areas of hand function.

In summary, this comprehensive hand function evaluation test has certain weaknesses. It does not include all types of manipulation patterns, does not evaluate quality of movement, and does not evaluate the static aspect of prehension. These weaknesses might be addressed through further factor analysis with other hand function evaluations. Continued revision of the standard hand function evaluations employed in the clinic can lead to more effective and efficient tests of hand function.

References


