Effects of Aging on Adult Hand Function

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Key Words: hand functions • hand grasp evaluation

The effects that normal aging have on adult hand function and functional performance are not well understood. An empirical study was conducted examining relationships between prehension pattern type and frequency, hand strength, and performance time in functional tasks. Four groups of 10 adults were selected by age and gender, ranging from 24 to 87 years. Subjects were asked to pour milk into a cup and remove money from a wallet while being videotaped. Prehension patterns were identified with a functionally based classification system. Grip and three types of pinch were measured with a dynamometer and a pinch gauge.

Prehension pattern selection did not seem to differ with age. Statistically significant differences in age were found for prehension pattern frequency, hand strength, and performance time. Nondysfunctional older subjects were observed resetting identical prehension patterns secondary to lateral pinch weakness, which contributed to increased prehension pattern frequency and performance time.

Hand function seemed to remain stable until age 65 years, after which it diminished slowly. After age 75 years, age differences in performance were most apparent.

The hand is an integral part of normal human function. Quality of performance in daily living skills, recreational, and vocational pursuits is influenced by adequate hand function. Functional abilities are dependent on anatomical integrity, muscle strength, sensation, and dexterity (McPhee, 1987). Early studies emphasizing the categorization and function of the anatomical structures of the adult hand provided a foundation for the scientific study of hand movements. Despite the use of differing theoretical frameworks and terminology, researchers directly or indirectly emphasized the importance of hands as functional tools. Despite the abundance of studies of adult hand use, there is a paucity of research relating aging to hand function (Aniansson, Rundgren, & Sperling, 1980; Lundgren-Linquist & Sperling, 1983; Sperling, 1980). The purposes of this study were to identify prehension patterns used by adults of differing ages while performing two common tasks and to examine correlates to strength and performance time.

Literature Review

Because of the disparity in terminology used by many authors in the literature, it is important to define four terms used in this project. These are prehension, prehensile patterns, grip, and pinch. Prehension is defined as the static act of the hand while holding an object. Prehensile patterns refer to the series of purposeful motions used to manipulate objects. Grip occurs when objects are held by the thumb or fingers or both and the palm of the hand. In pinch, any one finger or combination of fingers is used to manipulate objects in coordination with thumb movements, without contact with the palm. Thus, grip and pinch are differentiated by the role of the palm.

The study of prehensile movements of the hand developed from the need to classify disability of the hand resulting from industrial accidents. As early authors sought to rate the loss of overall hand function after injury, they identified specific normal hand movements, thus defining basic terminology (Barratt, 1955; Bechtol, 1954; Griffiths, 1943; Kirkpatrick, 1956; McBride, 1942; Slocum & Pratt, 1946). This process of identification of prehension patterns resulted in differing interpretations of their type, basic purpose, and relation to occupational requirements. Later researchers attempted to clarify these aspects of hand use (Landsmeer, 1962; Napier, 1956) as well as emphasize the specific mechanisms necessary for effective hand function. Within the last two decades attempts have been made by many authors to integrate these earlier works, to identify fundamental movements, and to standardize terminology in the study of the human hand (Bendz, 1974; Jacobson & Sperling, 1976; Kamakura, Matsuo, Ishii, Mitsuboshi, & Miura, 1980; Skerik, Weiss, & Flatt, 1971; Smith & Benge, 1985).

Of the literature cited above, half were reports of observational studies (Bechtol, 1954; Bendz, 1974; Kamakura, Matsuo, Ishii, Mitsuboshi, & Miura, 1980; Skerik, Weiss, & Flatt, 1971; Smith & Benge, 1985).
The remaining authors documented their opinions (Barratt, 1955; Griffiths, 1948; Jacobson & Sperling, 1976; Landsmeer, 1962; McBride, 1942; Napier, 1956; Slocum & Pratt, 1946). Only two of the formal studies included the ages of their subjects. Bectol tested adults ranging in age from 25 to 65 years, and the Kamakura study used subjects aged 27 to 37 years. It is not known if the earlier research was conducted with elderly subjects. Emphasis seemed to be on establishing normative data on adult hand function without differentiation for age.

The next phase in hand research was consideration of the method of study. Many authors seemed to agree on how prehension patterns should be identified, despite the lack of standardized terminology (Smith & Benge, 1962) and a universal prehension classification system. Because the human hand is a functional unit, it should be analyzed through examination of the role of each component part (Kaplan, 1953) through functional task analysis. Analysis of prehension patterns through examination of activities of daily living skills was conducted as early as 1955 by Taylor and Schwartz. Only within the last decade has age been considered a factor in hand function (Aniansson et al., 1980; Baron, Dutils, Berkson, Lander, & Becker, 1987; Lundgren-Linquist & Sperling, 1983; Sperling, 1980). Research with functional task analysis was not aggressively pursued until the last two decades (Aniansson et al., 1980; Kamakura et al., 1980; Lundgren-Linquist & Sperling, 1983; Sollerman & Sperling, 1978; Sperling, 1980; Sperling & Jacobson-Sollerman, 1977).

For several decades it has been assumed that adults over age 65 years use the same basic patterns of movement as younger adults. These assumptions have never been tested. Until the mid-1970s, research on hand function specific to the elderly was neglected. More recent studies have examined the functional use of the upper extremity in the nondysfunctional elderly (Aniansson et al., 1980; Lundgren-Linquist & Sperling, 1983; Sperling, 1980). These authors were the first to examine the relationship between hand strength, coordination, and functional performance in activities of daily living tasks with elderly subjects associated with normal aging. In a series of three articles, they showed that decreases in hand strength with age have a positive correlation to decreased functional performance in tasks requiring strength or dexterity skills or both.

The component parts of this study are the eight prehension patterns that make up the Hand-Grip Classification system devised by Sollerman and Sperling (1978). In their study, they purposefully identified the main patterns common to several activities of daily living tasks.

The patterns were divided into four finger grips (pinch) and four volar grips (grip). The four finger grips or pinches included pulp pinch, lateral pinch, tripod pinch, and five-finger pinch. Pulp pinch occurs when the thumb and index or middle finger(s) hold objects. When the thumb and radial side of the index finger hold an object, lateral pinch occurs. Tripod pinch occurs when the thumb, index, and middle fingers surround the object. Contact with the web space between the thumb and index finger may or may not occur. Five-finger pinch is defined as prehension occurring when the thumb and all fingers hold the object without contact with the palm.

Sollerman and Sperling also identified four volar grips: diagonal volar grip, transverse volar grip, spherical volar grip, and extension grip. Diagonal grip occurs when the thumb holds the object against all four fingers. The object contacts the palm at a diagonal axis. An object is held in a transverse grip when it is held between the thumb and fingers at a transverse axis to the hand. The spherical volar grip occurs when the thumb and fingers surround the object, contacting the palm. When the thumb and fingers hold the object with interphalangeal extension and palmar contact, extension grip is formed. Lateral pinch is the most commonly used grip bilaterally. In this study, their classification system was used to describe the hand function of adults to establish baseline normative data.

Often analysis of hand function of elderly persons is subjectively inferred from normative data obtained from the performance of younger adults. The comparison of adults with varied age ranges provides more objective baseline information regarding their similarities and differences and can help explain variations in performance. This study was designed to examine functional differences to determine whether they are within normal parameters or show reduced skills levels secondary to normal aging.

Method

Subjects

The nonrandom sample for this study consisted of 20 men and 20 women volunteers divided equally by age and gender into four groups. There were 5 men and 5 women in each group. The preset range of ages determined subject assignment to a specified group. Subjects in Group 1 were aged 77 to 87 years ($M = 80.2$ years, $SD = 3.03$), in Group 2, 67 to 74 years ($M = 70.2$ years, $SD = 2.56$), in Group 3, 46 to 64 years ($M = 56.9$ years, $SD = 6.64$), and in Group 4, 24 to 40 years ($M = 35.2$ years, $SD = 4.81$). For all groups combined, $M = 60.1$ years and $SD = 22.22$. Groups 1 and 2 were chosen from a local hospital. Twenty volunteer subjects were recruited through written invitations from five hospital departments, from a total of about 100 employees. These departments were occupational therapy, speech pathology, housekeeping, physical therapy, and nursing. Groups 3 and 4 lived in a community retirement residence. All subjects were screened with the same criteria. These included the lack of any neurological condition, the lack of present or past physical injury causing disability of either upper extremity, absence of upper
extremity fractures within 2 years, lack of sensory deficits, and functional visual acuity with or without correction.

**Equipment**

One of the most important characteristics of the hand is strength (Swanson, Matev, & de Groot, 1970). The Jamar Dynamometer\(^1\) has been proven to be a valid, reliable instrument for measuring transverse volar grip strength (Fess & Moran, 1981; Fike & Rousseau, 1982; Flood-Joy & Mathiowetz, 1987; Kellor, Frost, Silberberg, Iversen, & Cummings, 1971; Peterson, Patrick, Connor, & Conklin, 1989; Schmidt & Toews, 1970). The B & L Pinch Gauge\(^2\) has also been shown to accurately measure pulp pinch, lateral pinch, and tripod pinch (Apfel, 1986; Mathiowetz, Weber, Volland, & Kashman, 1984; Mathiowetz, Volland, Kashman, & Weber, 1985). These instruments seemed most appropriate for the purposes of this study.

The transverse volar grip of each subject was tested with a Jamar dynamometer based on the guidelines of the American Society of Hand Therapists (Fess & Moran, 1981), as interpreted by Mathiowetz et al. (1984). Each subject was seated with humerus adducted in neutral rotation, elbow flexed to 90\(^\circ\), and forearm in neutral. Following this protocol, grip strength of each hand was defined as the average of three repetitions using the dynamometer with the handle set in the second position measured in pounds.

The B & L pinch gauge was used to test lateral pinch, pulp pinch, and 3-point pinch using identical body and arm positioning as with the dynamometer. All fingers were flexed for each repetition. All pinches were measured as the average of three repetitions in pounds. The same instruments were used to test all subjects. Calibrations were checked before and after each of the eight data collection sessions according to the technique described by Mathiowetz et al. (1984), using a suspended known weight.

An objective method of recording sequential movements of both hands at normal speed was needed. Some researchers have successfully used cameras and reflective equipment to record hand movements (Brattgard, Paulsson, & Peterssen, 1971; Close & Kidd, 1969; Kamakura et al., 1980; Sperling & Jacobson-Sollerman, 1977). A VHS video camera was selected to provide an uninterrupted permanent record of events in real time. Subjects performed the study tasks on a tabletop in front of two large mirrors that were hinged together and set at about a 120\(^\circ\) angle behind the test pad (see Figure 1). The camera was set on a tripod at a fixed height and angle. The equipment set-up was identical for each subject. All timing was set by the researcher manually through the camera digital clock.

**Procedure**

Each subject participated in both stages of the study in one session. Hand strength was tested, and then subjects performed two common functional tasks. The first task, opening a milk carton and pouring milk into a cup, was chosen for its emphasis on bilateral hand strength. The second task, removing money from a wallet, challenged bilateral dexterity. All strength measurements, handedness, prehension patterns, and times were recorded on separate forms for each subject. All testing occurred in a nondistractible environment.

In strength testing, each subject was shown the correct positioning prior to each strength measurement. All right hand measurements for each category were taken first. Each subject followed the same sequence: transverse volar grip, lateral pinch, pulp pinch, and 3-point pinch. All scores were averaged.

Functional tasks. Before operationalizing the study method design, I conducted a pilot study with 5 men and 5 women using identical tasks as described. Several aspects of the study set-up were finalized to optimize the results, involving angles and locations of the mirrors, angle and location of the video camera, choice of the milk carton size, selection of the wallet style, starting position of the milk carton, amount of money to be removed from the wallet, and type of cup used. Instructions were given before the performance of both tasks. Between them, there was a 1-min break. Each subject was seated at a table in front of mirrors, with the video camera behind him or her on the left.

Identical quarts of milk were used for each subject.

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\(^1\) Manufactured by Asimow Engineering Company, Los Angeles, CA 90024.

\(^2\) Manufactured by B & L Engineering, Santa Fe Springs, CA 90670.
The pilot subjects preferred the quart size over other sizes used. I believe that the quart size is more commonly used than the pint or half gallon sizes. All quarts were refrigerated until the time of the test to control for the stiffness of the waxed carton. Each carton was placed on a rectangular pad at midline, with the end marked open facing the subject. In the pilot study, the open end was turned in the direction of the dominant hand. However, because several subjects turned the carton to varied angles, I decided to allow the subject the opportunity to control positioning starting from identical placement. A transparent cup provided the most visibility to determine hand placement and completion of the task.

Verbal instructions were given before each functional task, as follows. For the first task, each subject was told, "Please open the milk carton, pour a full cup of milk, and replace the carton and the cup onto the pad in front of you on the table. After you finish, I will replace the first task with the second one during the break."

Although many styles were considered, the wallet chosen did not seem to be gender specific. It had a rectangular folding style with five compartments. The paper money compartment ran the length and width of the wallet. The coin compartment was secured with a zipper. The three remaining compartments were unused and sized for pictures or credit cards. The wallet folded and was secured by a snap. When subjects in the pilot study were asked to remove all of the money in the wallet, they tended to dump the money out without using a variety of prehensile patterns. However, when asked to remove a portion of the money, a greater variety of hand movements was evoked. For the final study, a total of $2.61, consisting of two one-dollar bills, two quarters, one dime, and one penny, was used. Each subject was asked to remove one dollar, one quarter, the dime, and the penny.

Before the onset of the study, subjects were given as much time as they thought they required to familiarize themselves with the design of the wallet. They were allowed to open and close all compartments, but not to remove any money.

For the wallet task, the instructions were, "Please remove $1.36 from the wallet, placing the money anywhere on the pad on the table in front of you. When you have finished, close up the wallet completely and place it anywhere on the square."

For both tasks, overall timing began when I gave each subject the cue to start and stop. Actual performance time began when either hand made contact with the test item. Task completion time for the milk carton task ended when the milk hit the bottom of a transparent cup and for the wallet task when the closed wallet was placed on the pad after the correct amount of money was removed. Two types of observation were used to identify the Sollerman and Sperling prehension patterns. First, the videotapes were viewed as often as needed until each pattern was accurately labeled. With slow-motion analysis, pattern identifications were verified. Next, the patterns were sequenced, ranked in order of frequency, and recorded on forms.

**Results**

The data from this study were analyzed with descriptive and inferential statistics. Each prehension pattern was ordinarily ranked for each group for each task for each hand. Variables included age, prehension pattern type, prehension pattern frequency, performance time, and hand strength. Statistical measures involved analysis of variance (ANOVA) with the Tukey test for post hoc comparisons when the results were significant, the Kendall's tau correlation coefficient, and the Jonckheere-Terpstra Test for ordered alternatives. Level of significance was set at .05. Gender comparisons were not included in this project.

**Age and Prehension Pattern Type**

In the milk task, the commonly used patterns observed were pulp pinch, lateral pinch, five-finger pinch, and transverse volar grip for all groups for both hands. The ANOVA revealed significant differences only in left hand tripod pinch (MS = .82 [error = .20], DF = 3 [error = 36], F = 4.07 [p ≤ .01]) and right hand lateral pinch (MS = 2.75 [error = .80], DF = 3 [error = 36], F = 3.41 [p ≤ .05]). The range for mean square values for all left hand prehension patterns for the first task was from .03 to 1.49, with a standard error of .03 to 1.01. The F values ranged from .53 to 2.50. Mean square values for the right hand ranged from .03 to 2.75 with error of .03 to 1.10; F values were .10 to 3.41. A general trend showed an increase in use of pinch with age.

Variation in prehension pattern ranking was greater for the wallet task, and identical rankings between groups were fewer. Pulp pinch and lateral pinch ranked first or second for all groups. Also, all subjects used more pinch than grip patterns. The ANOVA showed no significant differences with age for any left prehension pattern types. Mean square values ranged from .10 to 15.95, with a standard error of .53 to 6.19; F values were from .06 to 2.58. Significant differences were observed for right transverse volar grip (MS = 1.20 [error = .24], DF = 3 [error = 36], F = 4.91 [p ≤ .01]).

Mean square values ranged from .27 to 11.69 with an error of .24 to 6.24; F values were .58 to 4.91. The results of a post hoc Tukey test showed significant differences between all group comparisons.

**Age and Prehension Pattern Frequency**

In the first task, the oldest subjects showed the highest mean frequencies for each of the left hand prehension patterns and for the total of all patterns (see Table 1).
Table 1
Comparison of Age Groups and Prehension Pattern Frequency for Both Hands

<table>
<thead>
<tr>
<th>Source</th>
<th>Task 1</th>
<th>Task 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DF</td>
<td>MS</td>
</tr>
<tr>
<td>Left hand</td>
<td>3</td>
<td>19.33</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>4.26</td>
</tr>
<tr>
<td>Right hand</td>
<td>3</td>
<td>10.73</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>2.76</td>
</tr>
</tbody>
</table>

Note: Comparisons were made with analysis of variance. *p ≤ .05, **p ≤ .01.

Tukey tests showed that Group 1 used significantly more prehension patterns than either Group 3 or Group 4. For the right hand, subjects in Group 1 showed the highest frequency for four of the prehension patterns and for the total patterns (see Table 1). Significant differences were between Groups 1 and 4.

The pattern frequencies for the wallet task for the left hand were quite variable. The oldest subjects used more lateral pinch, tripod pinch, transverse volar grip, and total patterns than any other group. The ANOVA showed significant differences in mean total pattern frequency. Tukey tests showed that Group 1 used significantly more prehension patterns than Group 3. Although pattern frequency for right tripod pinch, five-finger pinch, and spherical grip tended to increase with age, no significant differences among age groups occurred.

Age and Performance Time

In both tasks, performance time differed significantly with age (see Table 2, Table 3). In the milk-pouring task, Tukey test analysis showed that Group 1 took significantly longer than Group 4. Using identical analysis for the wallet task, differences occurred between Groups 1 and 4, and between Groups 2 and 4.

Age and Hand Strength

Kendall’s tau analysis showed that measurements for both hands showed a significant negative relationship to age (see Table 4, Table 5). As age increased, hand strength decreased for all prehension patterns.

Hand Strength and Prehension Pattern Frequency

Left hand strength was compared with left total prehension pattern frequency. Right total hand strength was compared with right prehension pattern frequency. This was done for each task.

For the milk-pouring task, significant negative Jonckheere-Terpstra correlations occurred between prehension pattern frequency for all left hand patterns and hand strength. For left pulp pinch, $r = - .247, p = .039$ ($p ≤ .05$); for left lateral pinch, $r = - .305, p = .010$ ($p ≤ .01$); for left 3-point pinch, $r = - .374, p = .002$ ($p ≤ .01$); for left transversal grip, $r = - .369, p = .002$ ($p ≤ .01$); for right lateral pinch, $r = - .244, p = .045$ ($p ≤ .01$).

Table 2
Mean Performance Time for Age Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Task 1</th>
<th>Task 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>1</td>
<td>11.75</td>
<td>5.10</td>
</tr>
<tr>
<td>2</td>
<td>9.80</td>
<td>4.10</td>
</tr>
<tr>
<td>3</td>
<td>7.53</td>
<td>2.60</td>
</tr>
<tr>
<td>4</td>
<td>6.11</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Note: Time was measured in seconds.

Table 3
ANOVA for Comparison of Age Groups and Performance Time

<table>
<thead>
<tr>
<th>Source</th>
<th>Task 1</th>
<th>Task 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DF</td>
<td>MS</td>
</tr>
<tr>
<td>Age groups</td>
<td>3</td>
<td>61.77</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>14.51</td>
</tr>
</tbody>
</table>

Note: Comparisons were made with analysis of variance. Time was measured in seconds. *p ≤ .05, **p ≤ .01.

Table 4
Mean and Distribution of Hand Strength for Age Groups

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Left Hand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp pinch</td>
<td>9.50</td>
<td>2.84</td>
<td>13.80</td>
<td>2.93</td>
</tr>
<tr>
<td>SD</td>
<td>10.30</td>
<td>3.08</td>
<td>16.50</td>
<td>5.68</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td>15.80</td>
<td>4.06</td>
<td>19.60</td>
<td>8.00</td>
</tr>
<tr>
<td>SD</td>
<td>11.40</td>
<td>3.74</td>
<td>16.30</td>
<td>6.77</td>
</tr>
<tr>
<td>3-point pinch</td>
<td>12.60</td>
<td>5.57</td>
<td>19.70</td>
<td>4.87</td>
</tr>
<tr>
<td>SD</td>
<td>16.20</td>
<td>5.98</td>
<td>18.00</td>
<td>4.87</td>
</tr>
<tr>
<td>Transversal grip</td>
<td>47.70</td>
<td>24.78</td>
<td>81.00</td>
<td>18.57</td>
</tr>
<tr>
<td>SD</td>
<td>57.30</td>
<td>29.85</td>
<td>80.00</td>
<td>18.57</td>
</tr>
</tbody>
</table>

Right Hand

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Pulp pinch</td>
<td>9.60</td>
<td>2.70</td>
<td>15.10</td>
<td>5.25</td>
</tr>
<tr>
<td>SD</td>
<td>10.70</td>
<td>3.17</td>
<td>17.10</td>
<td>5.52</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td>15.10</td>
<td>5.25</td>
<td>20.50</td>
<td>5.31</td>
</tr>
<tr>
<td>SD</td>
<td>12.30</td>
<td>3.70</td>
<td>20.90</td>
<td>4.14</td>
</tr>
<tr>
<td>3-point pinch</td>
<td>13.50</td>
<td>4.06</td>
<td>18.60</td>
<td>6.18</td>
</tr>
<tr>
<td>SD</td>
<td>15.10</td>
<td>5.25</td>
<td>18.60</td>
<td>4.25</td>
</tr>
<tr>
<td>Transversal grip</td>
<td>57.20</td>
<td>24.78</td>
<td>88.70</td>
<td>21.52</td>
</tr>
<tr>
<td>SD</td>
<td>62.70</td>
<td>27.61</td>
<td>92.30</td>
<td>21.52</td>
</tr>
</tbody>
</table>

Note: Strength was measured in pounds.
Hand Strength and Performance Time

The strength of each hand was compared with performance time for each functional task. For the first task, significant Kendall’s tau correlations occurred between total prehension pattern frequency and performance time for both hands on both tasks. As the number of prehension patterns increased, performance time increased. For the first task, for left hand, $r = -0.756, p = .0001 (p \leq .01)$; for right hand, $r = -0.807, p = .001 (p \leq .01)$. For the second task, for left hand, $r = -0.609, p = .0001 (p \leq .01)$; for right hand, $r = -0.320, p = .0440 (p \leq .05)$.

Discussion

Current theory derived from the work of Slocum and Pratt (1946) and Napier (1956) states that hand use is obligated by the task, rather than the object. This refutes the work of previous researchers (Griffiths, 1943; McBride, 1942). Sperling and Jacobson-Sollerman (1977) confirmed that grip choice was task bound and that grips varied with the same objects depending on the task purpose. These findings were supported by the results of this study. Among all age groups, there were more similarities in prehension pattern type selection than differences, indicating that prehension pattern type use seems stable with age into late adulthood.

The most commonly used patterns for all groups for both tasks were lateral pinch, pulp pinch, five-finger grip, and transverse volar grip. These findings corresponded to the common grip types in activities of daily living identified by Sollerman and Sperling (1978). The most frequently ranked patterns may have been obligated by the requirements of the task, rather than age.

Subjects in the two oldest groups used almost twice as many prehension patterns for the milk-pouring task and about a third more patterns for the wallet task than the younger groups. Analysis of pattern frequency may have identified underlying causes for this occurrence. Older subjects reset their hand position much more frequently and repeated many identical pairs of prehension patterns. This resulted in higher pattern frequencies despite similar choices of pattern selection. The reset phenomenon may have been due to errors in initial hand placement, inability to compensate for awkward positioning secondary to decreases in strength and dexterity, or responses to subtle losses in sensation by the older subjects.

The results of this study substantiate data in the literature that prove that performance time increases with age. Mean performance time for the first task for the

### Table 5

Comparison of Age Groups and Hand Strength for Both Hands

<table>
<thead>
<tr>
<th>Measurement</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left hand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp pinch</td>
<td>-0.303</td>
<td>.014*</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td>-0.342</td>
<td>.005**</td>
</tr>
<tr>
<td>3-point pinch</td>
<td>-0.368</td>
<td>.011**</td>
</tr>
<tr>
<td>Transversal grip</td>
<td>-0.363</td>
<td>.003**</td>
</tr>
<tr>
<td>Right hand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp pinch</td>
<td>-0.310</td>
<td>.011*</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td>-0.329</td>
<td>.007**</td>
</tr>
<tr>
<td>3-point pinch</td>
<td>-0.310</td>
<td>.010**</td>
</tr>
<tr>
<td>Transversal grip</td>
<td>-0.402</td>
<td>.001**</td>
</tr>
</tbody>
</table>

Note: Comparisons were made with Kendall’s tau correlation coefficient.

*.05. **p ≤ .01.

.05. As strength decreased, the number of prehension patterns increased. Although the association between the right hand strength and right prehension patterns appears similar to that for the left hand, the relationships were not generally significant. Right lateral pinch was the only significant correlation. Correlation values for right pulp pinch, right 3-point pinch, and right transversal grip ranged from -0.165 to -0.244. The probability values ranged from .45 to .179.

In the wallet task, trends seemed to indicate that as prehension pattern frequency increased, strength decreased. Jonckheere-Terpstra correlations showed no significant correlations between prehension pattern frequency and hand strength for the left hand. Correlation values ranged from -0.111 to -0.221 with $p$ values of .060 to .334. The correlation values for the right hand were from -0.086 to -0.226, with $p$ values ranging from .05 to .424. Only right pulp pinch showed a significant correlation with prehension pattern frequency, $r = -0.226, p = .050 (p \leq .05)$.

Hand Strength and Performance Time

The strength of each hand was compared with performance time for each functional task. For the first task, significant Kendall’s tau correlations occurred between performance time and strength of right lateral pinch, left and right 3-point pinch, and left and right transverse volar grip. As strength of those patterns decreased with age, performance time increased. Left correlation values ranged from -0.115 to -0.421 with $p$ values from .007 to .479. Right correlation values ranged from -0.170 to -0.392 with $p$ values of .03 to .29. For the first task, for left 3-point pinch, $r = -0.421, p = .007 (p \leq .01)$; for left transversal grip, $r = -0.401, p = .010 (p \leq .01)$; for right lateral pinch, $r = -0.345, p = .050 (p \leq .05)$; for right 3-point pinch, $r = -0.376, p = .026 (p \leq .05)$; for right transversal grip, $r = -0.392, p = .012 (p \leq .05)$.

Correlative analysis showed no statistically significant associations between hand strength and performance time for either hand for the second task. No age differences between variables were found. Left hand correlations ranged from -.058 to -0.238 with $p$ values of .139 to .718. Right hand probability scores ranged from -.032 to -.144 with $p$ values of .373 to .841.

Prehension Pattern Frequency and Performance Time

The total pattern frequency for each hand was correlated with performance time. Significant Kendall’s tau correlations occurred between total prehension pattern frequency and performance time for both hands on both tasks. As the number of prehension patterns increased, performance time increased. For the first task, for left hand, $r = -0.756, p = .0001 (p \leq .01)$; for right hand, $r = -0.807, p = .001 (p \leq .01)$. For the second task, for left hand, $r = -0.609, p = .0001 (p \leq .01)$; for right hand, $r = -0.320, p = .0440 (p \leq .05)$.

Discussion

Current theory derived from the work of Slocum and Pratt (1946) and Napier (1956) states that hand use is obligated by the task, rather than the object. This refutes the work of previous researchers (Griffiths, 1943; McBride, 1942). Sperling and Jacobson-Sollerman (1977) confirmed that grip choice was task bound and that grips varied with the same objects depending on the task purpose. These findings were supported by the results of this study. Among all age groups, there were more similarities in prehension pattern type selection than differences, indicating that prehension pattern type use seems stable with age into late adulthood.

The most commonly used patterns for all groups for both tasks were lateral pinch, pulp pinch, five-finger grip, and transverse volar grip. These findings corresponded to the common grip types in activities of daily living identified by Sollerman and Sperling (1978). The most frequently ranked patterns may have been obligated by the requirements of the task, rather than age.

Subjects in the two oldest groups used almost twice as many prehension patterns for the milk-pouring task and about a third more patterns for the wallet task than the younger groups. Analysis of pattern frequency may have identified underlying causes for this occurrence. Older subjects reset their hand position much more frequently and repeated many identical pairs of prehension patterns. This resulted in higher pattern frequencies despite similar choices of pattern selection. The reset phenomenon may have been due to errors in initial hand placement, inability to compensate for awkward positioning secondary to decreases in strength and dexterity, or responses to subtle losses in sensation by the older subjects.

The results of this study substantiate data in the literature that prove that performance time increases with age. Mean performance time for the first task for the
oldest group was almost twice that for the youngest group. For the second task, mean time was five times greater for the oldest subjects.

The results of this study also replicate others' findings that strength decreases with age. These results corroborate the work of others who have correlated diminished hand strength with decreased ability to perform functional tasks (Aniansson et al., 1980; Lundgren-Linquist & Sperling, 1983; Sperling, 1980). Of particular interest to this study are the findings of these authors who observed that strength of lateral pinch has a significant correlation to performance of tasks requiring strength and dexterity.

Lateral pinch was commonly used in the first task. Older subjects reset their hands, possibly to accommodate for diminished force of lateral pinch in the milk-pouring task. Decreased strength also significantly increased performance time for the elderly subjects. Generally, they had difficulty producing the force required to open the milk carton spout. They often compensated by trying to substitute pulp pinch. This approach was much less effective because pulp pinch is usually weaker than lateral pinch.

The wallet task required more dexterous movements: pulp pinch weakness seems to have contributed to higher pattern frequency by affecting the accuracy of coordination. However, hand strength of the older subjects was sufficient to complete the wallet task without significantly increasing performance time.

Lateral pinch and transverse volar grip strength were most frequently associated with decreased performance in a functional task requiring strength. In this study, nondysfunctional older subjects were observed resetting identical prehension patterns secondary to lateral pinch weakness, which contributed to increased pattern frequency and performance time. In a task requiring dexterity, resetting of precision prehension patterns increased performance time. Therefore, there are differences in functional performance associated with the changes occurring with normal aging, as substantiated by the results of this study.

Study Limitations

Several limitations may have influenced the outcome of this study. The sample size was small and nonrandomized, and only two functional tasks were chosen, thus generalizability to the nondysfunctional population may have been reduced. All prehension patterns were identified and analyzed subjectively by one researcher, thus reliability was not tested. Timing was also subjectively based.

Performance of the elderly subjects may have been more susceptible to the influence of extraneous variables, such as familiarity with test-taking, test anxiety, level of comfort with the presence of a video camera, threshold for sustained activity, and cognitive skills (e.g., memory, sequencing, problem-solving). As a result, several older subjects requested re-explanation of the directions.

Finally, it was assumed that subjects gave reliable demographic information in meeting the study criteria for nondysfunctional adults. The presence of any sensory or motor impairments could have skewed the results.

Conclusion

The manipulative ability of the human hand is crucial to routine functioning. Normal prehension patterns coordinate movement to produce effective force and dexterity for performance in daily functioning. Occupational therapists should be concerned with understanding normal adult hand movements and functional activities analysis for the facilitation of independence in the rehabilitation. Results of this study show that age was a primary influence on all dependent variables for both functional tasks. The elderly do have difficulty with some functional tasks requiring strength and dexterity (Aniansson et al., 1980; Lundgren-Linquist & Sperling, 1983; Sperling, 1980).

Several concepts pertinent to occupational therapy practice with the elderly have been shown. Most age differences in performance were between the oldest and youngest subjects. Functional ability seems to remain stable until age 65 years, after which it diminishes slowly. After age 75 years, age differences are more apparent.

Historically, occupational therapists have used activities to strengthen all pinch and grip types to improve hand function. Ideally, functional task analysis would identify the specific prehension patterns needed as a basis of accurately assessing performance deficits. Then, evaluation and treatment approaches would address problem areas contributing to decreased function. Thus, differences in hand function occurring as a result of natural aging sequelae should be an important priority for occupational therapy study.

Additional research is needed with a larger, more random sample with similar methodology or using manual muscle testing or electromyographic study to ascertain the role(s) of individual muscles in functional task performance with normal aging. More research is needed with video cameras to standardize methodology for hand study. Further studies could focus on standardization of the Sollerman and Sperling Hand-Grip classification system for functional task analysis. The relationship between hand strength and functional abilities also needs further exploration. ▲

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