Objective. This study examined preschool children's acquisition of fine motor skills and functional performance when occupational therapy services are included as part of the educational program. It also investigated the relationships among fine motor skills and functional performance in self-care, mobility, and social function.

Method. Twenty-six preschool children who received weekly occupational therapy were studied. Measurements of their in-hand manipulation, tool use, eye-hand coordination, grasping strength, and functional performance in self-care, mobility, and social function were taken at the beginning and end of the school year.

Results. Raw and scaled scores showed significant improvements in all skill areas; standard scores showed slight improvement in eye-hand coordination and mobility function. Correlations of the motor skill tests with the functional performance scales using year-end data revealed significant correlations for in-hand manipulation, eye-hand coordination, and grasping strength with self-care function and mobility.

Conclusions. The results demonstrate the level of change that occurs in fine motor skill and self-care, mobility, and social function during the course of the school year for preschoolers with moderate fine motor delays. The relationships found in the year-end testing imply that performance in underlying fine motor skills as the focus of occupational therapy intervention is associated with self-care and mobility function.

Occupational therapists are required to deliver services to eligible preschool children (Individuals With Disabilities Education Act [IDEA], 1990 [Public Law 101-476]). The occupational therapist's goals with preschoolers who have motor delays or motor impairments are frequently to improve fine motor skills, with particular emphasis on eye-hand coordination and manipulation; to enhance play skills; and to increase self-care function. The approach used to address these goals depends on the basis of motor delay, the degree of impairment, and the developmental level of the child. Often, the therapist analyzes the sensorimotor foundations required to perform a functional skill then uses strategies and techniques to improve those underlying sensorimotor skills with the assumption that improvements in the underlying motor skills will result in increased function.

Although the literature (Coster & Haley, 1992; Dunn, Brown, & McGuigan, 1994; Letts et al., 1994) has helped us reframe assumed relationships among underlying skills, performance, function, and context, very little research has examined the relationship of underlying sensorimotor skills to functional performance in areas such as self-care, mobility, and social interaction. Haley and colleagues designed a model of motor outcome evaluation that suggested a hierarchy of motor outcomes (Coster & Haley, 1992; Haley & Baryza, 1990). The first and
At the second level, evaluation of motor control and skill includes coordinated sequences of movement in precision skills such as stacking blocks, manipulating small objects, and grasping a utensil or tool. These skills are generally evaluated by observing the child’s performance of specific tasks, such as those on a standardized developmental evaluation. At the model’s highest level, the child’s ability to perform daily activities is evaluated. Evaluation of function at this level is best accomplished through interview with a caregiver who is familiar with the child’s daily activity and has knowledge about the child’s performance in a variety of contexts. New assessments such as the Pediatric Assessment of Disability Inventory (PEDI) (Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992), which measures adaptive motor function in self-care, mobility, and social function, allow us to measure functional outcomes. Other new assessments for infants such as the Alberta Infant Motor Scale (Piper & Darragh, 1994), the Toddler and Infant Motor Evaluation (Miller & Roai, 1994), and the Posture and Fine Motor Assessment of Infants (Case-Smith & Biggby, 1993) allow us to measure motor control and motor skills at lower levels of the model. Often, therapists analyze motor control and skills through observation of the child and with motor analysis that records the child’s unique assets and limitations in posture and movement without reference to standard scores or formal tests (Case-Smith, 1993; Royeen, 1992).

Occupational Therapy Services to Promote Fine Motor Skills in Preschool Children

Occupational therapists have developed techniques to promote fine motor skill development and functional performance in young children. The techniques advocated by several researchers (Benbow, Hanft, & Marsh, 1992; Boehmte, 1988; Case-Smith, 1993; Exner, 1995; Myers, 1992) emphasize development of underlying motor skills. Myers recommended small manipulatives to improve use of the intrinsic hand muscles and to develop blended grasping patterns (i.e., those that require mobility and stability). Exner (1995) described a range of graded fine motor activities to promote increasing precision in in-hand manipulation. Other authors (Erhart, 1992; Schneck & Battaglia, 1992; Tseng & Cermak, 1993) have emphasized the role of visual–motor skill in functional activities such as self-care, tool use, and handwriting. Typical occupational therapy goals include improving bilateral coordination and dynamic tool use required in preschool activities such as cutting, coloring, and printing. Other goals include improved dressing skills such as managing fasteners, zippers, and shoelaces.

Although improvement in in-hand manipulation and eye–hand coordination should logically generalize into increases in self-care independence, we have little evidence that they do. In an earlier study, I found that in-hand manipulation skill, as measured by a timed test of object rotation, and eye–hand coordination, as measured by the Motor Accuracy Test (Ayres, 1980), did not have a major relationship to self-care, as measured by the PEDI (Case-Smith, 1995). It should be noted that the items on the PEDI Self-Care Scale include using fasteners; donning shirt, pants, and shoes; washing and bathing; and demonstrating many other tasks that require hand skills, precision grasp, and manipulation. These results imply that self-care skills seem to be more influenced by environmental factors and the context of performance than the child’s underlying fine motor abilities. Furthermore, these results supported the conclusions of Coster and Haley (1992) and Haley, Baryza, and Blanchard (1993) that because direct predictive relationships do not necessarily exist among the motor outcome variables, comprehensive evaluation and intervention should include all levels of the motor function.

Some practice theories consider the context of performance as critically important to enhancing the child’s functional abilities and support the importance of therapy activities that generalize underlying skills into daily living function (Humphry, Jewell, & Rosenberger, 1995; Kamm, Thelen, & Jensen, 1990; Mathiowetz & Haugen, 1994). New efforts are being forged to combine activities to improve individual isolated skills with opportunities in the environment for increasing and generalizing those skills (Dunn et al., 1994).

Efficacy of Occupational Therapy With Preschool Children

Research regarding the efficacy of occupational therapy with children has produced inconsistent results. Parette, Hendricks, and Rock (1991) described a lack of consensus regarding which therapeutic interventions were most effective for children with cerebral palsy. Studies of the efficacy of neurodevelopmental treatment (Kluzik, Fetters, & Coryell, 1990; Law et al., 1991; Palmer et al., 1988; Piper et al., 1986) with a variety of designs have produced disparate results. Although some evidence exists to support the short-term benefits of intervention, evidence of long-term gains as a result of therapy has not been established (Campbell, 1991). We do not have strong data to indicate that significant developmental and functional change occurs due to occupational therapy intervention (Law et al., 1991; Parette et al., 1991). Researchers incur two problems: lack of reliable and valid instruments and difficulty implementing sound research designs because of the ethical considerations that limit their ability to obtain a control group similar to the group of children receiving therapy (Campbell, 1991; Palisano, 1991).

Harris (1990) recommended that therapists collect outcome data that focus on functional independence and
use current models of interdisciplinary integrated practice. Haley, Coster, and Ludlow (1991) also recommended that occupational therapists and physical therapists focus their efforts on the functional outcomes that seem to make a difference in the lives of the family and the child. They suggested that by systematically measuring functional outcomes, therapists can improve intervention programs and gain insight into the functional development of the child for refining practice models and techniques (Haley et al., 1991).

**Purpose**

The purpose of this study was to research the degree and type of change in fine motor skills and functional performance achieved by children in preschool educational programs over the course of a school year. All the children received direct occupational therapy services as part of their educational program. The fine motor skills measured (i.e., in-hand manipulation, tool use, eye-hand coordination, grasping strength) are skills that children refine during the preschool years and use in functional performance (i.e., self-care, mobility, social function). The guiding questions of this research were as follows:

1. Do preschool children who receive weekly occupational therapy demonstrate improvement in fine motor skills and functional performance over the course of the school year?
2. If they achieve significant improvement in test raw scores, are these improvements significant when normative standard scores are compared?
3. Are the outcome measures for functional performance in self-care, mobility, and social function significantly related to underlying motor skills (i.e., in-hand manipulation, tool use, eye-hand coordination, and grasping strength)?

**Method**

**Subjects**

In the initial recruitment of subjects, I contacted 10 occupational therapists who worked with preschoolers to participate in the study. Six were interested in participating and identified children who received regular direct occupational therapy services, were known to attend school regularly (i.e., were absent 2 days or fewer each month), and met the study’s criteria. These criteria were chronological age of 4 years to 6 years, fine motor delay of two standard deviations or more on the Peabody Developmental Motor Scale–Fine Motor, and cognitive skills at 4 years or higher as measured by a developmental curriculum.

Of the 30 subjects who were tested at the beginning of the school year, 26 remained in the study and completed the testing at the end of the school year. Of the 4 subjects lost, 2 moved out of the district, 1 received a diagnosis of juvenile rheumatoid arthritis, and 1 was unavailable at the time of retesting. The subjects, 17 boys and 9 girls, were from eight different preschools. All the preschool programs included children with and without developmental delays; the majority of children in each classroom received special education, speech therapy, and occupational therapy services. The diagnoses of the subjects were developmental delay (n = 20), spastic diparesis cerebral palsy (n = 2), Fragile X syndrome (n = 1), and mental retardation (n = 3). The age range of the sample at the beginning of the study was 4 years to 6 years, with a mean age of 4 years, 8 months. Four subjects were African-American and 22 were Caucasian.

**Intervention**

Six occupational therapists provided weekly services to the subjects, as written on their individualized education plan (IEP). Areas targeted for occupational therapy intervention were increased in-hand manipulation skills; use of tools such as pencils, crayons, and scissors; and eye-hand coordination. The subjects’ IEP goals included improved performance in manipulation and eye-hand coordination.

The preschool classrooms used integrated models of service delivery in which some of the subjects who attended were typically developing and others had developmental delays. Each setting had access to occupational, physical, and speech therapy services. Many of the subjects received speech therapy in addition to occupational therapy. All of the subjects received 30-min to 45-min weekly occupational therapy sessions. Often, these services were delivered in the classroom and comprised individualized activities, consultation with the teacher and other team members who worked with the child (10 min to 15 min), and small groups that participated in sensorimotor and fine motor activities (an additional 15 min to 30 min).

To meet the study goals, intervention activities were designed to develop underlying fine motor foundations (i.e., motor control and skills) for more skilled hand use and improved control of isolated finger and thumb movements. The occupational therapists involved the subjects in small object manipulation and sensory experiences meant to be generalized into improved tool use and increased functional abilities. Many of the therapy activities emphasized the development of (a) wrist stability and extension, (b) flexibility and stability of the palmar arches, (c) isolated finger use, (d) thumb stability and mobility, and (e) control of radial fingers with ulnar fingers stabilized. These components seemed to be fundamental to dynamic control of tools, such as a pen, and handling of small objects (e.g., moving them in and out of the hand).

Activities specifically designed to reach these goals were also recommended to the teachers to incorporate in...
classroom activities. Examples of activities used to meet these objectives were finger painting activities on easels and vertical surfaces, finding small objects in resistive materials such as play clay, using magnetic wands to pick up small metal objects, or creating animals from pipe cleaners or other textured materials. In addition to small object manipulation, eye-hand coordination and tool use were addressed with tools that required intrinsic muscle use (e.g., tweezers, eye droppers, or small tongs). Activities were tailored to the individual needs of the subjects, and consultation was specific to the curriculum and interests of the teachers. Often, the occupational therapist adapted the art, cooking, or fine motor activities planned by the teacher by suggesting specific materials or methods. As a result, the classroom activities often met the individualized needs of the subjects with specific occupational therapy goals.

**Instrument**

Difference levels of motor outcomes were evaluated with the model of Haley et al. (1993). At the motor control and motor skills level, the accuracy and speed of specific movements were measured. For purposes of this study, the motor control and motor skill variables that were measured included in-hand manipulation, pencil and scissors grasping patterns, eye-hand coordination, and grasping strength. All these qualitative motor control and motor skills variables are believed to underlie adaptive motor function or functional performance as measured with the PEDI.

**Motor control and motor skills variables.** Before testing in-hand manipulation, the subject was asked to draw a happy face and to print his or her name. The hand selected to draw the happy face was determined to be the subject’s preferred hand, and that hand was used in completing the in-hand manipulation tests rotation and translation. In the rotation test, the subject prehended a 1-in. peg from a pegboard, rotated it 180° in his or her fingertips, and returned it to its peghole. I have used this testing procedure, modeled from the work of Exner (1992) and Pehoski (1994), in a series of studies (Case-Smith, 1991, 1993, 1995). Two timed scores were obtained for the subject after turning five pegs with the preferred hand. The test was given twice; times were added to provide a summary score. The number of times the subject dropped or stabilized the peg on another surface was also totaled into a “drop” score.

The translation test was a timed task of palm-to-fingers and fingers-to-palm translation with the 1-in. peg. The child sequentially prehended two, three, four, and five pegs, holding them in the palm and then replacing them into the pegboard. In each task, the subject was instructed to pick up the pegs one at a time and hide them in his or her palm, then replace them in the pegholes after all had been prehended. The sum of the times in seconds required to complete each task was used in the data analysis. Drop scores were also computed for the translation test as the total number of times during each task the subject dropped or stabilized the pegs on another surface.

The Motor Accuracy Test of the Southern California Sensory Integration Test (Ayres, 1980) was used to measure eye-hand coordination and motor planning. Adjusted raw scores that accounted for the time required to complete the task, as well as the subject’s accuracy in tracing the line with his or her preferred hand, were used in the analysis.

**Pencil grasp** was evaluated with the developmental progression described by Schneck (1991) and Schneck and Henderson (1990). In this progression, each type of pencil grasp is ranked from 1 to 10 through a developmentally based hierarchy. The pencil grasp was rated while the subject drew the happy face and printed his or her name. The best grasping pattern observed counted as the subject’s score.

**Grasping strength** was measured with a bulb dynamometer. The highest scores of two attempts were used in the analysis. Grasping strength of the subject’s preferred hand was recorded in pounds of pressure.

**Functional performance.** The PEDI was used to evaluate the subjects’ functional capabilities. This comprehensive inventory consisted of 197 functional skills items that measure self-care, mobility, and social function (Haley et al., 1992). It has a separate section that measured the amount of caregiver assistance and modification required; this section was not used in the data analysis. Scores on the PEDI were based on a 45-min to 60-min interview with each subject’s primary caregiver. The primary caregiver was asked to identify which functional skills the subject performed consistently or with competence. Because the PEDI scores were based on the primary caregiver’s judgment of performance, the results reflected the subject’s abilities across environments and not his or her performance at one point in time. Items involved several performance components, including fine motor skills. The Self-Care Scale, in particular, is based on items that require fine motor skills (e.g., dressing, bathing, and fastening). The Mobility Scale includes some items that involve fine motor skill (e.g., carries objects, manages seat belt and car door, and moves objects on floor). The Social Function Scale includes items that measure play with toys and objects and performance of household chores.
Data Collection

The subjects were tested at the beginning (October 1993) and end (May or June 1994) of the school year. Testing was completed by myself and two occupational therapy graduate students who had 5 years of experience working with preschoolers and who were trained in test administration. The raters were, therefore, not blind to the purpose of the study. The subjects were given all the motor assessments in one sitting, which generally required 45 min to 50 min. Each subject was tested in a quiet area of the classroom, separated from the other students, or in the therapy area with the materials described and child-sized table and chairs. The PEDI was administered to the primary caregiver by myself and a research assistant who was trained in its administration. Most of the interviews were conducted over the telephone; however, three of the primary caregivers participated in face-to-face interviews that required about 45 min. The data from the PEDI were entered into a personal computer with the PEDI software package, which generates standard and scaled scores.

Data Analysis

The PEDI raw, scaled, and normative standard scores were calculated to obtain a comprehensive picture of the changes in the subjects' functional performance. The raw scores show the actual number of functional skills achieved at each measurement time. The scaled scores account for item difficulty by converting scores to an equal interval, criterion-referenced scale of 0 to 100. The standard scores compare each subject's score with that of his or her typically developing peers and are based on a mean of 50 and a standard deviation of 10.

To analyze whether a subject improved in motor skills over the course of the academic year, paired t tests were computed for the motor assessments that generated interval data. Two tests, the pencil grasp and the scissors grasp, resulted in ordinal data; therefore, the Wilcoxon signed rank test was used to analyze prescore and postscore differences. To examine the relationships between the foundational motor skills and the subject's functional performance, Pearson correlation and Spearman rank order correlation coefficients were computed with the posttest scores. The two types of coefficients were similar for all of the measures; therefore, Pearson correlation coefficients were used in the regression analysis. Multiple linear regression analyses using pairwise and listwise deletions (Kerlinger & Pedhazur, 1973) were computed with the end-of-the-year data to determine whether the subjects' scores on the motor control and motor skill tests could predict functional performance as measured by the PEDI scales. Regression analysis with pairwise deletion eliminated subjects with missing data in specific analyses such that every possible correlation was computed; listwise deletion eliminated any subject with incomplete data from all the analyses. In the regression with listwise deletion, six subjects were eliminated because they did not complete two of the tests. Therefore, the regression with pairwise deletion was the preferred analysis because this procedure used all available data.

Results

Table 1 lists the results of the raw scores for all of the motor assessments administered at the beginning and end of the school year. Scaled scores for the PEDI were also reported to demonstrate functional skill change that considers item difficulty. Comparisons using paired t tests and the Wilcoxon test indicated significant improvement in all the motor assessments, except grasping strength.

The normative standard scores calculated for the two evaluations that had published standard scores, the Motor Accuracy Test and the PEDI, took into account differences in ages at the beginning of the study and the change in age from the beginning to the end of the school year. On the basis of the mean standard scores and results of the paired t tests (see Table 2), the subjects demon-

| Table 1 |
|------------------|------------------|------------------|------------------|
| **Assessment**   | **Pretest Scores** | **Posttest Scores** | **p Value** |
|                  | **Mean (ND)**    | **Mean (ND)**    |                  |
| Motor components |                  |                  |                  |
| In-hand manipulation |                |                  |                  |
| Rotation time (sec) | 52.5 (19.7)   | 41.1 (17.1)   | .000**          |
| Rotation drops     | 6.6 (4.4)      | 4.6 (3.8)     | .001**          |
| Translation time (sec) | 113.8 (27.5) | 85.0 (18.6)  | .000**          |
| Translation drops  | 14.2 (7.9)     | 9.7 (6.5)     | .01**           |
| Grasping strength  | 15.5 (5.1)     | 16.7 (4.9)    | 1.07            |
| Tool use           | 7.0 (3.4)      | 9.0 (3.8)     | .001**          |
| Pencil grasp       | 5.0 (3.4)      | 5.0 (3.8)     | .001**          |
| Scissors grasp     |                  |                  |                  |
| Eye-hand coordination |            |                  |                  |
| Motor accuracy     |                  |                  |                  |
| (adjusted for time)| 122.4 (18.4)  | 155.9 (16.1) | .000**          |
| Functional performance |            |                  |                  |
| PEDI               |                  |                  |                  |
| Raw scores         |                  |                  |                  |
| Self-care          | 58.5 (8.4)     | 63.6 (6.5)    | .000**          |
| Mobility           | 55.0 (6.4)     | 56.8 (4.4)    | .01**           |
| Social function    | 46.4 (8.5)     | 50.7 (6.6)    | .001**          |
| Scaled scores      |                  |                  |                  |
| Self-care          | 69.9 (6.2)     | 74.5 (7.4)    | .000**          |
| Mobility           | 88.9 (12.4)    | 93.7 (11.7)   | .001**          |
| Social function    | 60.1 (6.1)     | 62.7 (5.5)    | .011**          |

Note: Lower scores for in-hand manipulation motor components indicate improvement. PEDI = Pediatric Evaluation of Disabilities Inventory.
*Test computed for all interval data scores.
**Median scores provided for ordinal data.
***Wilcoxon signed rank test calculated.
†Significant at p < .05
**Significant at p < .005
strated improvement in the Motor Accuracy Test and the PEDI Mobility Scale.

To evaluate which motor performance or motor skill scores contributed to end-of-the-year functional performance, correlations of raw test scores and regression analyses were computed, with the PEDI as the dependent variable (see Table 3). The motor assessments that demonstrated significant correlations with the Self-Care Scale were rotation time, \(-.616\) (the negative correlation indicates that greater speed was associated with better self-care performance); grasping strength, \(.549\); pencil grasp, \(.609\); scissors grasp, \(.437\); and motor accuracy, \(.606\). In the linear regression with pairwise deletion, in-hand manipulations, as measured by rotation time and grasping strength, were significant predictors of raw scores on self-care function, independently accounting for 38% and 25% of the variance \(R^2 = .63\).

The motor skill scores that correlated with the PEDI Mobility Scale were rotation time, \(-.666\) (negative correlations indicated speed and accuracy were positively related to increased mobility); rotation drops, \(-.533\); translation drops, \(-.736\); pencil grasp, \(.431\); scissors grasp, \(.505\); and motor accuracy, \(.431\). When linear regression with pairwise deletion was computed, all the in-hand manipulation tests entered into the equation, accounting for almost 100% of the variance. The partial correlations (those computed after the effects of the first variable to enter the regression equation were deleted) seemed to be artificially inflated through the pairwise procedure. Therefore, a multiple regression analysis without listwise deletion was computed; only translation drops entered the equation as a significant predictor of mobility function, accounting for 54% of the variance.

Two of the motor skills tests were significantly correlated with the PEDI Social Function Scale, grasping strength and pencil grasp. In the regression analysis, grasping strength alone was the only motor skill variable capable of predicting social function scores, accounting for 25% of the variance.

**Discussion**

This study provides information regarding the types and level of progress achieved by preschool children with fine motor delays who receive regular occupational therapy services over the course of a school year. The services include therapist-directed activities, consultation, and small group activities and emphasize the development of hand skills, manipulation, and eye-hand coordination as the basis for competence in functional performance.

The subjects demonstrated significant progress in all measures of motor skills, except grasping strength. Significant improvements were achieved in speed and accuracy in in-hand manipulation tasks, in the developmental level of pencil and scissors grasp, and in motor accuracy. The improvement in motor accuracy standard scores over the course of the year was also statistically and clinically significant. As a measure of motor planning and eye-hand coordination, the Motor Accuracy Test requires the child to trace a long, curved line (Ayres, 1989). This tracing task is similar to activities that the subjects performed frequently in the classroom. In addition, tracing skills were frequently listed as objectives on the subjects’ IEPs. Therefore, this activity was regularly practiced and was a focus of the teacher’s planned activities. Although the occupational therapists were aware of these goals, their intervention activities probably did not include practice in tracing but engaged the subjects in a variety of eye-hand activities that combined eye-hand skills with object manipulation or object placement (e.g., magnets, stickers placed on a vertical surface, push pins on a cork board) to copy or create line designs. The research design of this study did not allow for identification of the specific variables that accounted for progress made in motor accuracy scores.

The subjects also improved in functional performance; changes in the raw and scaled scores on the PEDI are significant. Although many of the changes were statistically significant, the design of the study did not allow for comparison of the changes made with what might be

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**Table 2**

<table>
<thead>
<tr>
<th>Assessment/Scale</th>
<th>Pretest(^a)</th>
<th>Posttest(^b)</th>
<th>(p) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor accuracy (standard adjusted scores)</td>
<td>-1.45 (1.7)</td>
<td>-54</td>
<td>.014*</td>
</tr>
<tr>
<td>PEDI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-care</td>
<td>3.62 (8.5)</td>
<td>37.6 (12.0)</td>
<td>.544</td>
</tr>
<tr>
<td>Mobility</td>
<td>40.0 (20.1)</td>
<td>46.5 (17.9)</td>
<td>.031*</td>
</tr>
<tr>
<td>Social function</td>
<td>29.7 (9.3)</td>
<td>30.6 (9.0)</td>
<td>.675</td>
</tr>
</tbody>
</table>

Note. PEDI = Pediatric Evaluation of Disabilities Inventory.

\(^a\)Pretest evaluation was conducted October 1993.

\(^b\)Posttest evaluation was conducted May or June 1994.

*Significant at \(p < .05\)

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**Table 3**

<table>
<thead>
<tr>
<th>Motor Skill Assessment</th>
<th>PEDI Scales (Raw Scores)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-Care</td>
</tr>
<tr>
<td>In-hand manipulation</td>
<td>-0.616**</td>
</tr>
<tr>
<td>Rotation time</td>
<td>-0.311</td>
</tr>
<tr>
<td>Rotation drops</td>
<td>-0.407</td>
</tr>
<tr>
<td>Translation time</td>
<td>-0.288</td>
</tr>
<tr>
<td>Translation drops</td>
<td>-0.549**</td>
</tr>
<tr>
<td>Grasping strength</td>
<td>.609**</td>
</tr>
<tr>
<td>Tool use</td>
<td>.437*</td>
</tr>
<tr>
<td>Pencil grasp</td>
<td>.606**</td>
</tr>
</tbody>
</table>

Note. PEDI = Pediatric Evaluation of Disabilities Inventory.

**Significant at \(p < .05\)**

**Significant at \(p < .005\)**
expected in similar preschoolers who did not receive services. Such a control group was not available, given that occupational therapy services are mandated by law for eligible preschoolers (IDEA, 1990).

Given these overall positive results, a series of analyses were performed to estimate whether the progress made was greater than what would be expected with maturation alone and with the foundational motor skill variables associated with the progress in functional performance. On the basis of the PEDI normative standard scores, the subjects made gains in self-care and social function that were not significant and gains in mobility that were significant at \( p < .05 \). The small gains made by the subjects in the present study in the PEDI normative scores indicate that children with mild to moderate fine motor delays achieve slight improvement during the preschool years when compared with the changes observed in their peers without disabilities (i.e., the norming sample). The increased normative scores represent positive results when maturation trends for children with certain disabilities exhibit a pattern of falling further behind their peers without disabilities over time (Anwar, 1986; Harris, 1981; Molnar, 1992). In particular, the gain of 5 points on the PEDI Self-Care Scale over the course of the year appears meaningful. Each point represents a new skill that the subject has achieved; therefore, on average, each subject gained five new self-care skills. The clinical significance increased when scaled scores that account for item difficulty were compared (\( \bar{X}_1 - \bar{X}_2 = 4.57, F = -4.27, p = .000 \)).

Raw, scaled, and normative standard scores were examined to interpret the change in mobility scores. The mean raw scores increased by 2 points; however, the gains made represented a significant amount of improvement when scaled or normative standard scores were used. The proportionately large increase in scaled scores indicates that the subjects achieved relatively difficult mobility items over the course of the school year. Accomplishment of these higher level, difficult items seems to represent important changes in the subjects. It should also be noted that the mean standard scores for mobility are within one standard deviation of the mean for the norming population, and at the end of the year, the subjects demonstrated mobility skills similar to those of typical children.

The least amount of improvement on raw and scaled scores was achieved in social function. This quantitative result was verified in the primary caregiver interviews. Many of the caregivers expressed continued concern about the subjects’ social function. Several researchers have found that social skills improve slowly given a comprehensive intervention approach (Guralnick & Wehmeyer, 1984; Peterson & McConnell, 1993).

**Relationships Among Variables**

The correlations and regression analyses reveal the relationships between the foundational motor skills and motor control that are the focus of occupational therapy intervention and the subjects’ functional performance as reported by the primary caregivers through the PEDI. In-hand manipulation, as measured by rotation time, and grasping strength, is significantly related to and emerges as a significant influence of self-care function. Hand strength may be important to many dressing tasks (e.g., pulling up pants, fastening snaps, donning shoes). In addition, the items on the PEDI Self-Care Scale often involve manipulation, particularly the items that are first observed in 4-year-olds to 6-year-olds (e.g., those related to bathing and dressing skills). These relationships and the significant correlations of pencil grasp, scissors grasp, and motor accuracy scores suggest that the motor skills emphasized during occupational therapy may be important contributing factors to functional performance in self-care. The generalization of improved motor skills into functional activities is continuously promoted in the classroom by the teachers, aides, and occupational therapists with practice of self-feeding, fastening and dressing, hand washing, and tooth brushing skills. Occupational therapy intervention often includes fastening and tying practice in dress-up activities and with dolls. Overall, the moderate correlations among the fine motor skill measures and self-care function suggest that these variables are relevant to the development of self-care but in and of themselves do not completely account for mastery of self-care function. The importance of self-care independence as determined by the family’s values and culture and the opportunities afforded to the child at home often have a strong influence on the child’s performance of self-care tasks (Case-Smith, 1994; Vincent, Salisbury, Strain, McCormick, & Tessier, 1990).

Almost all of the motor skill and motor control tests relate to mobility function. A weaker relationship between in-hand manipulation and mobility was expected given that the PEDI Mobility Scale primarily measures walking balance, ambulation, and stair climbing rather than manipulation and fine motor skill. Closer examination of the scale items, however, reveals that the highest level mobility items (and the ones that many of the subjects gained during the year) involve fine motor skill and manipulation. These items, which seem to produce the variance in scores, include “manages seat belt in car,” “opens and closes car door,” “carries fragile or spillable objects,” and “opens and closes inside and outside doors.” The relationship between in-hand manipulation scores and mobility may demonstrate that achievement of functional mobility involves manipulation and fine motor skills to manage doors, handles, and locks and to carry objects in addition to gross motor and ambulation skills. The child’s functional performance in mobility is often influenced by opportunities and barriers within the environment; the preschoolers in this study seemed to have had the mobility opportunities and experiences needed.
to generalize motor skills into functional performance, making these levels of motor outcomes congruent for the subjects.

Social function, as measured by the PEDI, involves skills across many domains (e.g., language, cognition, and psychosocial skills). A relationship with motor skills was not expected. Of the two motor skills that correlated with social function, grasping strength was the only significant variable in the regression analysis. This relationship suggests that physical strength may influence the child’s ability to enter into and sustain social interaction. The scale items that seemed to produce the variance in subjects’ scores were those that required physical strength (e.g., “carries out household chores” and “explored community settings”). However, for most of the items, the relationship to strength is not apparent or implied, and the correlation may reflect the influence of a third unknown variable on both scales, such as an underlying “maturation” factor or general physical stamina for active play (three of the items measured play skills).

Another issue that would affect the relationships expressed among the variables is the relative sensitivity of the different measures. PEDI items are scored dichotomously (yes or no answers). After sufficient capability has been demonstrated for a skill to be scored yes, no additional information about improvements in that skill can be obtained (e.g., in efficiency, speed, accuracy). Therefore, after a certain level of competence is achieved, improvement in fine motor control scores is no longer captured. The fine motor skill measures were sensitive to qualitative changes in how the subject accomplished the task (i.e., speed and accuracy were captured) and did not have a ceiling effect.

In an earlier study that used the data from these subjects at the beginning of the year (Case-Smith, 1995), the correlations between foundational motor skills and functional performance found in the year-end test data reported here were not demonstrated. Several interpretations are possible. The relations between foundational motor skills and functional performance that emerged by the end of the year may be due to the daily opportunities provided in the classroom to generalize motor skill into self-care and mobility function. Because the PEDI is based on the primary caregivers’ judgment, their experiences must be considered in interpreting the results. At the beginning of the year, the primary caregivers may have been less aware of all the subjects’ skills and of typical developmental expectations. Thus, they may have given the subjects fewer opportunities to demonstrate all their functional capabilities. By the end of the year, the primary caregivers may have learned methods, such as verbal cuing to prompt dressing or physical assistance in play activities, which helped the subjects generalize motor skills into functional performance at home. In the year-end PEDI interviews, it was apparent that the primary caregivers were in touch with the IEP goals, were aware of preschool activities, and had implemented adapted methods introduced by the occupational therapist and teacher to increase the subjects’ functional performance. Use of adapted methods may have been another reason why component skill status did not predict more of the variance in the PEDI scores because the adapted or compensatory methods would increase functional levels without a concurrent increase in foundational skills. After the year-end IEP meetings, the primary caregivers and team members may have had consensus regarding appropriate expectations and experiences for the subjects and by extension, greater congruence between the subjects’ underlying motor skills and the self-care and mobility opportunities provided.

**Limitations**

This study had a number of limitations that must be considered in interpreting the results. Without the same data from a control group of preschoolers who did not receive occupational therapy services, conclusions about the effect of occupational therapy services cannot be made. Numerous authors (Campbell, 1991; Parette et al., 1991; Piper, 1990) have suggested that different models of therapy be compared to provide contrast groups and therefore gain evidence of the effect of different models of practice. When planning this study, it was anticipated that by using six different therapists from preschools throughout the area, different models of practice would emerge that could be compared. However, review of the therapists’ descriptions of therapy showed their services to be remarkably similar, and logical comparisons could not be made.

Because the therapists who tested the 26 subjects were not blind to the study’s purpose, some bias on scores could have resulted. However, most of the tests were observational and fairly objective (e.g., they were timed, counted, or measured with a line measure), which reduced the subjectivity of the testing procedure and the likelihood of bias. The most subjective tests seemed to be the rating of pencil and scissors grasp, which have almost no data to support their reliability and validity. Therefore, the pencil and scissors grasp results should be interpreted with great caution.

**Conclusion**

This descriptive study demonstrates the progress made in motor skills and functional performance in preschoolers over the course of the school year. When year-end skills were compared with skills at the beginning of the year, significant progress was documented. Comparison of beginning and end-of-the-year standard scores demonstrate that the subjects slightly improved in functional performance when normative standard scores were compared. Although the change was not statistically significant, the
skills gained appear to have clinical relevance. The occupational therapists' contributions to the development of functional abilities cannot be directly measured in integrated programming such as that in which the subjects participated, but fine motor skill and motor control (the focus of the occupational therapists' intervention) are significantly related to the subjects' functional performance at the end of the school year. In particular, in-hand manipulation and eye-hand coordination were highly associated with functional performance in self-care and mobility. These promising results suggest that additional outcome data be collected to demonstrate the types of progress made by preschool children with motor delays who receive interdisciplinary intervention that includes occupational therapy. ▲

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