Measuring Dexterity in Children Using the Nine-hole Peg Test

Janet L. Poole, PhD, OTR/L
Patricia A. Burtner, PhD, OTR/L
Theresa A. Torres
Occupational Therapy Graduate Program
Department of Orthopaedics and Rehabilitation
University of New Mexico
Albuquerque, New Mexico

Cheryl Kirk McMullen, OTR/L
EASI
Albuquerque, New Mexico

Amy Markham, OTR/L
Albuquerque Public Schools
Albuquerque, New Mexico

Michelle Lee Marcum, OTR/L
Ridgecrest Healthcare
Phoenix, Arizona

Jennifer Bradley Anderson, OTR/L
Education Assessment Systems Inc.
Shiprock, New Mexico

Clifford Qualls, PhD
Clinical Research Center
University of New Mexico School of Medicine
Albuquerque, New Mexico

ABSTRACT: The purpose of this study was to measure dexterity in children aged 4–19 years using the Nine-hole Peg Test. Four hundred and six children were tested with their dominant hand and then their nondominant hand. A commercial version of the Nine-hole Peg Test was used. An analysis of variance showed a main effect for age, gender, and hand dominance. Speed of dexterity improved with age. In all age groups, females performed faster than males. Participants performed faster with the dominant hand than the nondominant hand. The normative data collected provide information for comparing scores to children with different diagnostic categories to screen for fine motor difficulties.

J HAND THER. 2005;18:348–351.

The performance of many tasks of daily living, school activities, and play require fine motor dexterity. Although it has been reported that 10% of school-age children have difficulty with fine motor tasks,[1] fine motor screening is not routinely performed for school age children. Smith et al.[2] suggested that one explanation may be the lack of a simple and easy tool for screening and proposed that the Nine-hole Peg Test (9-HPT) may be an appropriate screening tool. The 9-HPT is a timed test in which nine pegs are inserted and removed from nine holes in the pegboard with each hand. The original norms for the 9-HPT for adults were published by Kellor et al.[3] At that time, the pegboard was not commercially available and required construction of the pegboard and pegs from wood. Since that time, several commercial versions of the test have been marketed.[4]

The Smith et al.[2] study developed normative data for children 5–10 years of age using a modified version of the Sammons, Preston and Rolyan peg test. In this study, high interrater reliability ($r_s > 0.99$) and test–retest reliability ($r_s = 0.81$ and 0.79) were reported. Furthermore, concurrent validity of the 9-HPT was examined by correlating scores on the 9-HPT with scores on the Purdue Pegboard, which

Portions of this manuscript were presented at the New Mexico Occupational Therapy Association Conference in Albuquerque, NM, November 2001.

Supported in part by the Clinical Research Center at UNM School of Medicine (Grant M01RR0097).

Address correspondence and reprint request to Dr. Poole, Occupational Therapy Graduate Program, Department of Orthopaedics and Rehabilitation, University of New Mexico, MSC09 5240, Albuquerque, NM 87131-0001; e-mail: <jpoole@salud.unm.edu>.

doi:10.1197/j.jht.2005.04.003

yielded a correlation coefficient of 0.80 for the dominant hand and 0.74 for the nondominant hand.[2] The mean completion time was also shown to be different for typical developing children and children in special education.[2] Thus, the 9-HPT has the potential to be a quick and easy to administer tool for screening fine motor problems in children. However, these researchers used a modified version of the commercially available pegboard for the normative, reliability and validity study. Thus, the scores in the Smith et al. study may not be representative of scores on the commercially available version.[4] Another study did use the commercially available version without modifications to establish norms for dexterity in Korean elementary school age children.[5] However, the age range in both studies was limited: 5–10 years in the Smith et al.[2] study and 7–12 years in the Yim et al.[5] study. Other studies have shown that dexterity continues to improve during adolescence,[6] and it has been suggested that adolescents do not have similar dexterity to adults.[7] Because the adult norms on the 9-HPT start at age 20,[8] there is no information regarding the performance of children between 12 and 20 years of age on this test. Therefore, the purpose of this study was to develop norms for school-age children as measured using the 9-HPT across a wider age range, and to provide initial normative data for 4–19-year-old children.

MATERIALS AND METHODS

Participants

Four hundred and six children from ages 4–19 years were tested (193 males and 213 females) (Table 1). The majority of the participants (n = 369) were right handed and 47 participants were left handed, which reflects the 10–15% estimate of left-handed people in the general population.[9] Handedness was identified by asking the participant or parent which hand was used for writing/drawing. Children with a parent-reported or self-reported history of neurologic, orthopaedic disability or with a special education classification were excluded from the study. Twenty-one percent of the participants were Hispanic, 2% were African American, and 1% were Native American; 86% were from urban areas. The sample represented diverse socioeconomic groups surrounding a large Western metropolitan area.

Procedure

After obtaining informed consent from the participant and/or parent, participants were tested individually by one member of the research team in a quiet location. Children were tested at a desk and chair of appropriate height with their feet supported on the floor. The procedure described by Mathiowetz et al.[8] was followed in this study. The pegboard was centered in front of the subject with the container side on the same side as the hand being tested. The dominant hand was tested first. Subjects completed one practice trial followed by the actual timed test for each hand. The instructions used were the same as those used by Mathiowetz et al. For the nondominant hand, the pegboard was turned so that the container was on the same side as the nondominant hand.

Interrater reliability was established by having the examiners simultaneously time 20 subjects. Intraclass correlations were 0.98 for the dominant hand and 0.96 for the nondominant hand.

TABLE 1. **Subject Characteristics: Age, Sex, and Hand Dominance**

	Males				*Females*			
Age (yr)	*N*	*Mean age (yr)*	*Right**	*Left**	*N*	*Mean age*	*Right**	*Left**
4–5	27	5.0	24	3	21	5.0	17	4
6–7	25	6.8	21	4	23	7.1	20	3
8–9	23	9.1	19	4	26	8.9	23	3
10–11	24	11.0	24	0	21	11.0	18	3
12–13	23	12.9	23	2	24	12.9	23	1
14–15	25	15.1	21	4	25	14.9	24	1
16–17	21	16.8	19	2	43	17.0	24	2
18–19	23	19.0	21	2	30	18.8	30	0

*Right- or left-hand dominance.

RESULTS

The means and standard deviations according to age, gender, and dominance are shown in Table 2. Data are presented in two-year age intervals. A mixed model analysis of variance was calculated to examine differences in dexterity times with age and gender for both the dominant and nondominant hands. There was a main effect for age ($F_{7,\ 372}$ = 140.95, $p < .0001$), gender ($F_{1,\ 372}$ = 12.50, $p < .0005$), and dominance (F1, 372 = 85.51, $p <$ .0001). Speed of dexterity improved with age. Male and female scores for each age group were combined and post hoc analyses using the least significant difference test were calculated to determine which ages differed in dexterity. For the dominant hand (Table 3), times for children 4–9 years old were significantly slower than each other and slower than children older than 10 years of age. Times for the 10–11-year-old children were similar to the 12–13 and 14–15 year olds, but were significantly slower than children aged 16 years and older. Times for the 12–13-year-old children were similar to the 14–15 year olds but slower than children older than 16 years of age. The 14–15-year-old children had times similar to the children older than 16 years of age. For the nondominant hand (Table 3), times for children

TABLE 2. **Mean Completion Time in Seconds by Age, Sex, and Hand Dominance**

Age range (yr)	Males					Females				
	N	Dominant	SD	Nondominant	SD	N	Dominant	SD	Nondominant	SD
4–5	27	29.8	3.8	34.5	5.9	21	30.2	6.3	33.2	6.2
6–7	25	25.5	6.0	28.5	6.6	23	22.5	2.3	25.9	5.2
8–9	23	19.9	3.9	21.7	4.3	26	18.7	1.9	21.2	3.2
10–11	24	18.9	4.1	20.2	3.3	21	16.7	3.4	19.0	3.1
12–13	25	18.0	2.5	18.4	2.6	24	17.1	1.8	18.1	2.2
14–15	25	18.0	2.7	18.6	1.8	25	16.8	2.4	18.1	1.8
16–17	21	16.9	2.0	17.1	2.4	43	15.8	1.9	17.1	1.8
18–19	23	16.1	1.6	16.7	1.2	30	16.1	2.1	17.4	2.0

between the ages of 4–9 years were significantly different from each other and significantly slower than children older than 10 years of age. Times for children between the ages of 10 and 15 years were similar, and times for children older than 12 years of age were similar. Participants performed faster with the dominant hand than with the nondominant hand. Females performed faster than the males. The only significant interaction was Dominance × Age ($F_{7,\ 372} = 5.53$, $p < .0001$). As children's ages increased, the difference in times between the dominant and nondominant hands decreased.

DISCUSSION

The data from this study support the conclusions from previous studies. That is, females perform faster in fine motor dexterity tests than males, and dominant hand scores are faster than nondominant scores.[2] Older children were faster than younger children, a finding that is different from findings in adults that show dexterity on the 9-HPT actually decreases with age.[8] This was the first study to examine changes in dexterity on the 9-HPT in children older than 12 years of age. Several studies suggested that dexterity scores as measured by the Purdue Pegboard change little in children older than 10 years of age.[10,11] Other studies reported that scores on the Purdue Pegboard did improve and that adult norms should not be used for children older than 10 years of age.[6,7] Our study also found changes in scores for the dominant hand in the participants older than 10 years of age in that the 10–13 year olds were significantly slower and showed greater variance than were children 16–19 years of age. For the nondominant hand, there were no significant differences in scores in children older than 12 years. In addition, the scores for our 16–19-year-old children were not significantly different from scores for the norms reported by Mathiowetz et al.[8] for adults aged 20–29 years (one-sample t-tests; all p-values were greater than 0.44). Thus, the adult norms for the 9-HPT should not be used for the dominant hand in children younger than 16 years but could be used for the nondominant hand for children older than 12 years of age.

Participants in our study in the 5–10-year-old groups were slightly slower overall than the participants in Smith et al.[2] study for both the dominant and nondominant hands. However, our study used the commercially available Sammons, Preston and Rolyan pegboard that was not adapted with the nonskid surface on the bottom or with the shock-absorbent surface, as was the pegboard in Smith et al.'s study. Times for our participants were slightly faster than those obtained by Yim et al.,[7] who did use a commercial-version pegboard.

This study was limited by the use of a convenience sample, self-reports to determine dominance, and the absence of medical conditions. Future studies might want to address a larger number of children and represent greater geographic, ethnic, and socioeconomic backgrounds.

CONCLUSION

The 9-HPT is commercially available, easy and quick to administer, portable, and requires minimal space and equipment. The 9-HPT has been shown to be sensitive to change in adults with neuromuscular and musculoskeletal disorders, and correlates with daily tasks requiring dexterity.[12–14] However, at the present time, no studies have used the 9-HPT

TABLE 3. **Comparison of Combined Mean Male and Female Times for Dominant and Nondominant Hands**

Hand	Age (yr) 4–5	6–7	8–9	10–11	12–13	14–15	16–17	18–19
Dominant	30.0_{a}	24.3_{b}	19.4_{c}	18.0_{d}	$17.5_{d,e}$	$17.4_{d,e,f}$	16.1_{f}	$16.4_{e,f}$
Nondominant	34.0_{a}	27.1_{b}	21.5_{c}	19.6_{d}	$18.3_{d,e}$	$18.4_{d,e}$	17.5_{e}	17.2_{e}

Note: Means in the same row sharing the same subscript are NOT significantly different at 0.05 in the least significant difference comparison.

to document dexterity variability in children with pathology, possibly because of the lack of normative data. Now that normative data exist from the present study, the test could be used as a screening tool for measuring dexterity in children. Furthermore, the 9-HPT may be particularly useful to measure and monitor hand dexterity in children who have hand injuries, who have undergone surgery, or who have diseases involving the hand (e.g., arthritis).

Acknowledgments

The authors wish to thank the students for their participation in this study. They also thank those who helped make this study possible: Lisa Brower, Sheryl Fleck, OTR/L, Anderson Academy, Albuquerque Academy Day Camp, Belen Public Schools, Butte Public Schools, Campfire Boys and Girls, East Mountain Schools, Menaul School, and Serendipity Day School. They thank all the subjects, schools, and programs who participated in this study. This study was completed as partial fulfillment of the Independent Study Project for the Bachelor of Science degree for Ms. Kirk and Ms. Markham at the University of New Mexico Occupational Therapy program.

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