Comparison of Pencil-Grip Patterns in First Graders With Good and Poor Writing Skills

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The purpose of this study was to compare nondysfunctional children with and without handwriting difficulties for an examination of grip and hand preference. Additionally, in the group of children with handwriting difficulties, the children with decreased proprioceptive-kinesthetic finger awareness were compared with the children without such a decrease. The results suggest that children with handwriting difficulties may demonstrate a lower grip score than children without handwriting problems. In addition, among children with poor handwriting, those with decreased proprioceptive-kinesthetic finger awareness may demonstrate a lower grip score than those with good proprioceptive-kinesthetic awareness. Children with poor handwriting also show less hand preference than those with good handwriting.

Handwriting is an important skill in the school-aged child's repertoire. For most children, the grip and motor responses involved in handwriting quickly become automatic. However, many children struggle to master handwriting skills. Unfortunately, studies of children with handwriting problems are limited, and few studies have been done to examine how the grips of children with poor handwriting differ from the grips of children with good handwriting.

Children with handwriting difficulties have been observed among various populations of children. Rubin and Henderson (1982) surveyed 82 teachers who taught approximately 2,500 children aged 9 to 10 years in a regular classroom. The teachers identified 307 children (204 boys and 103 girls) who had serious handwriting problems. The handwriting evaluation was based on six characteristics of writing: legibility, accuracy of letter formation, uniformity of letter size, uniformity of letter slant, spacing between letters and words, and alignment of lines of writing. In a study by Carter and Synolds (1974), teachers noted that a large percentage of children with learning disabilities manifested serious writing problems. The researchers described these children as having difficulty with “efficiency in the fluid, dexterous movement of writing” (p. 53) and as having a tendency to use an inordinate amount of mental and physical energy to write. Inferior pencil-grip patterns and handwriting problems have also been observed in children with spina bifida (Moss & Hogg, 1981) and with Down syndrome (Moss & Hogg, 1981).

Various factors must be considered in an evaluation of the acquisition of motor skills. Limitations imposed by any one of these contributing factors at any time in development may affect the level of performance attained (Connolly, 1973). The first step in skill acquisition is the building and organization of coordinated activity, including one's learning to assume the correct posture (Welford, 1951). In handwriting, this would include development of the correct pencil grip. If, however, the optimal posture is not learned correctly, then perfection of this skill becomes more difficult.

Grip is important because it allows the fine movements necessary for writing. The movement of the pen in a proximal-distal axis is made by the flexion or extension of the radial digits, especially at the interphalangeal joints (Long, Conrad, Hall, & Furler, 1970). This basic pattern may be supplemented by a certain amount of lateral deviation of the fingers, thereby giving a component of movement in the radioulnar axis. The principal movement is a simple flexion or extension synergy of the wrist and fingers used in writing that creates a vertical elongation of letters. The sequence of letters themselves and, to some extent, the horizontal component in their formation are the results of wrist actions (Cailliet, 1975). This movement may not be easily performed; to compensate for inadequate pencil manipulation, therefore, a child in ear-
ly elementary school may develop an awkward grasp. Callewaert (1963) suggested that the consequences of holding a pencil improperly are the poor formation of letters and the failure to join letters together to form words. Inscriptive movements (i.e., the actual drawing of letters) are difficult if the fingers are cramped on the pen so that the phalanges cannot move the pen delicately. Callewaert also noted that if the hand becomes fixed and pressed into the paper, then it does not slide easily along the horizontal line.

Comparisons have been made between children with good and poor handwriting. In a study comparing nondysfunctional and at-risk kindergarten children, the at-risk children with poor grip and posture did not show significantly lower scores on handwriting efficiency skills (i.e., upper extremity formation of symbols, arm movement across the paper, and fluency and speed) (Goodgold, 1983). Grip may not have discriminated between the two groups, because grip was defined in only four categories, and no differentiation was made between static and dynamic grip patterns.

Another study examined the fine motor and perceptual-motor skills of children identified by their teachers as having serious handwriting difficulties (Rubin & Henderson, 1982). On the basis of the results of the five subtests of the Test of Motor Impairment (Stott, Moyes, & Henderson, 1972), the children with poor handwriting were not significantly worse in fine motor skills, on average, than the control children. A wider range of scores did exist, however, among the group with poor handwriting, which indicates a greater spread of ability in the fine motor skills of those with poor handwriting, but no direct relationship. The children with poor handwriting were also less able to copy than were the control children, but the correlation between the children's test scores and their handwriting scores was only moderate. Poor copying, therefore, does not necessarily predict poor handwriting. Because poor copying ability is only one component of poor handwriting, other areas must be explored for possible difficulties.

Benbow (1987) investigated the differences in finger awareness, rotation ability, translation ability, and range of motion at the index metacarpophalangeal joint of nondysfunctional children aged 7.0 to 7.11 years. The subjects were separated into two groups—those who had developed a dynamic tripod grasp and those who exhibited a transitional grasp. An analysis revealed no significant between-groups differences on the four variables measured. Fewer than half of the subjects demonstrated the dynamic tripod grasp, which should be developed by the age of 6 years. Eighteen of 35 children in the transitional grip group demonstrated a four fingers grasp. 10 of these 18 children had developed isolated finger movement. Benbow noted, as did Schneck and Henderson (1990), a grip not identified as a normal variation of pencil grip in previous studies. In this grip, the pencil is held with the thumb tightly adducted over or under the index finger, which closes the web space completely. This grip was noted by Levine, Oberklaid, and Meltzer (1981) as a maladaptive grasp that would lead to serious problems in later grades, in which volume of writing and time constraints increase. Although the four sensory and motor factors studied by Benbow (1987) were not found to be significant in nondysfunctional 7-year-old children, these factors may be significant in dysfunctional populations. Levine et al. found finger agnosia to be a contributing factor in 12-year-olds who were experiencing trouble with written assignments. Finger agnosia was elicited with tasks involving imitative finger movement and finger differentiation.

In the early stages of motor skill learning, tactile and proprioceptive exploration and manipulation depend largely on visual control (Connolly, 1973). Vision is needed to define the task and oversee the hands. Once the nature and mechanics of the operation are learned, prepatterned movements appear. Visual analysis is then free for transfer to the next part of the program. Children with decreased tactile and proprioceptive-kinesthetic feedback from their hands continue to need visual monitoring in order to perform a handwriting task. These prepatterned movements may take longer to develop or may never develop in children with decreased tactile feedback. Handwriting, therefore, remains inefficient as demands become more difficult. Rubin and Henderson (1982) suggested that speed and level of skill in handwriting depend on script being produced automatically. If decreased tactile feedback from the hands limits pencil control, then script cannot be produced automatically, thus limiting the level of handwriting.

Levine et al. (1981) identified some children with learning disabilities who had problems in manipulating a pencil for writing but showed no fine motor deficits in other areas of performance. These children were imperceptive to proprioceptive-kinesthetic feedback from their hands. To compensate for this lack of somesthetic feedback, the children visually monitored their hands while writing, thus the writing task became inefficient. An additional compensation noted in these children was their tight grip of the pencil; this excess pressure provided some feedback from the joints as the motions were performed. Levine et al. further noted that many of these children demonstrated an awkward pencil grasp. An awkward grasp may not affect handwriting when minimal amounts are required, but when large amounts of written work are required, a poor grip may lead to fatigue as well as to slow, poor formation of letters.

Pencil grip may be influenced not only by decreased proprioceptive-kinesthetic feedback but also by lack of hand preference. In an earlier study, Schneck (1989) identified a relationship between the development of a preferred hand and the development of a mature grip. It was hypothesized that children who have not developed
a preferred hand may not have developed the more refined skills needed for good pencil control.

In the current study, I desired to document whether nondysfunctional children with handwriting problems differ in their grip patterns from nondysfunctional children without handwriting problems as well as to determine whether, among children with poor handwriting, those with decreased proprioceptive-kinesthetic input from their hands would demonstrate lower grip scores than those with normal proprioceptive-kinesthetic input, as measured by Levine et al. (1981). The following hypotheses were tested to compare nondysfunctional children with and without handwriting difficulties:

1. Children with handwriting difficulties will demonstrate less mature grips than will children without handwriting difficulties.
2. Among children with handwriting difficulties, those who demonstrate decreased proprioceptive-kinesthetic finger awareness will demonstrate less mature grips than those with normal proprioceptive-kinesthetic finger awareness.
3. Children with handwriting problems will show less preference for one hand than will children without handwriting problems.

Method

Subjects

The subjects of this study were 60 first-grade children from elementary schools in the greater Pittsburgh area. These children had no learning, physical, or behavioral problems, as reported by their parents or classroom teachers. Fifteen boys and 15 girls had handwriting difficulties, and 15 boys and 15 girls did not. The above classification of good or poor handwriting skills was made by the child's teacher and by three independent raters. The teacher and the three raters were asked to rate the child's handwriting on the basis of six characteristics judged to be either good or poor (Rubin & Henderson, 1982). The raters used a handwriting sample of a copied sentence and the printed alphabet obtained from each subject. The children who received a rating of poor handwriting were placed in Group 1, and the children who received a rating of good handwriting were placed in Group 2. Inclusion of each child in the study required that at least two of the three raters agree with the teacher's classification of good or poor handwriting. Three children were not included in this study due to lack of raters' agreement. Generally, 1 or 2 children per classroom were rated as having poor handwriting.

The children ranged in age from 6.0 to 7.1 years (mean age = 6.8 years). For the group with good handwriting skills, 28 children showed a right-hand preference; 1 child, a left-hand preference; and 1 child, no preference. For the group with poor handwriting skills, 22 children showed a right-hand preference; 2 children, a left-hand preference; and 6 children, no preference.

In the group of children with handwriting problems, 6 boys and 5 girls showed decreased proprioceptive-kinesthetic finger awareness, as measured by a score of 5 or below on the Imitative Finger Movement subtest of the Pediatric Early Elementary Examination (Levine, 1983). One additional girl with decreased proprioceptive-kinesthetic finger awareness was recruited to match the number of girls to boys.

Instrumentation

Pencil-grip assessment. The components of grip were observed through the use of a drawing task. Each child was presented with a 5 cm by 5 cm piece of paper. He or she was then given a sharpened No. 2 pencil and instructed to draw a diamond. The child was then given a new sheet of paper on which to repeat the drawing task. Grip posture was assessed with a 5-point rating system determined in an earlier study (Schneck, 1989), with 5 being the highest score possible. The scale was determined through the grouping together of those grips that had a mean age within 2 months, based on the mean grip scores obtained in the drawing task. The pencil-grip scale and operational definitions are shown in Table 1.

Lateral Consistency Test. Hand preference was measured with the Lateral Consistency Test, adapted from Lyle (1976). This test has 10 items requiring the use of one hand (e.g., pointing to a spot on the wall). Each child was instructed to perform the tasks, and the hand the child used was recorded. With the index of handedness described by Lederer (1939), it was calculated that a child with 80% hand preference used that hand significantly more often than the other hand ($p = .05$). Thus, if the child used the same hand to perform 80% or more of the items, that hand was scored as the preferred hand; otherwise, it was assumed that the child had not yet developed a preferred hand.

Imitative Finger Movement subtest. The Imitative Finger Movement subtest from the Pediatric Early Elementary Examination was administered to all of the children for an evaluation of proprioceptive-kinesthetic finger awareness. Each child was instructed to mirror the tester's finger movements without looking at his or her own fingers. The score was derived from the number of successful trials. The test was administered in a standardized manner according to the instruction manual (Levine, 1983).

Handwriting rating. The teachers were asked to rate the child's handwriting as either good or poor on the basis of the child's performance within the classroom setting. The criteria for rating handwriting were based on six characteristics: legibility, accuracy of letter formation, uniformity of letter size, uniformity of letter slant, spacing between letters and words, and alignment of lines of writ-
Table 1
Operational Definitions of Grip Posture and Score on the Pencil-Grip Assessment

<table>
<thead>
<tr>
<th>Score</th>
<th>Definition</th>
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<tr>
<td>1</td>
<td>Radial cross palmar grasp — Pencil positioned across palm projecting radially, held with fist, arm not supported on table, full arm movement (Morrison, 1978).</td>
</tr>
<tr>
<td>2</td>
<td>Palmar supinate grasp — Pencil positioned across palm projecting ulnarly, held with fist, arm not supported on table, full arm movement (Morrison, 1978).</td>
</tr>
<tr>
<td>3</td>
<td>Brush grasp — Pencil held in palm, held with fingers with eraser end of pencil positioned against palm, hand pronated on table, full arm movement, forearm positioned in air.</td>
</tr>
<tr>
<td>4</td>
<td>Grasp with extended fingers — Pencil held with fingers, wrist straight and pronated with slight ulnar deviation, forearm moves as a unit.</td>
</tr>
<tr>
<td>4</td>
<td>Static tripod grasp — Pencil stabilized against radial side of third digit by thumb pulp with index pulp on top of shaft, thumb stabilized in full opposition, wrist slightly extended and hand moves as a unit, pencil placed in open web space, forearm resting on table (Rosenthal &amp; Horton, 1971).</td>
</tr>
<tr>
<td>4</td>
<td>Cross thumb grasp — Fingers fisted loosely in palm, pencil held against index finger with thumb crossed over pencil toward index finger, finger and wrist movement, forearm positioned on table (Gesell, 1940).</td>
</tr>
<tr>
<td>4</td>
<td>Dynamic tripod grasp — Pencil stabilized against radial side of third digit by thumb pulp with index pulp on top of shaft of pencil, thumb stabilized in full opposition, wrist slightly extended, fourth and fifth digits flexed to stabilize metacarpophalangeal arch and third digit, localized movement of digits of tripod and wrist movements on table and horizontal strokes, forearm resting on table (Schneck, 1989).</td>
</tr>
<tr>
<td>5</td>
<td>Lateral tripod grasp — Pencil stabilized against radial side of third digit by thumb pulp with index pulp on top of shaft of pencil, thumb abducted and braced over or under anywhere along the lateral border of index finger, wrist slightly extended, fourth and fifth digits flexed to stabilize metacarpophalangeal arch and third digit, localized movement of digits of tripod and wrist movements on table and horizontal strokes, forearm resting on table (Schneck, 1989).</td>
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Note: A score of 1 is the lowest score obtainable; a score of 5, the highest.

1. Permission was obtained for the child to participate in the study.
2. The teacher was asked to rate the child’s handwriting as either good or poor on the basis of the six characteristics described above.
3. Each child was tested in a single session at the beginning of the school year. First, the child was positioned appropriately in a Tripp Trapp Chair1 with desk height at elbow level. Second, the Lateral Consistency Test was administered to determine handedness. Third, the child was requested to perform the drawing task, from which grip and posture were observed and recorded. Fourth, the child was administered the Imitative Finger Movement test subtest for evaluation of proprioceptive finger awareness. Last, the child was asked to print the lowercase alphabet and to copy the sentence, “The quick brown fox jumped over the lazy dog.”
4. The handwriting sample of the sentence that the child copied was given to the three independent raters, who rated the sample as either good or poor on the basis of the six characteristics described earlier.
5. The subjects were divided into the appropriate group depending on the match in rating between the teacher and the independent raters (a child was included in the study only if the ratings of at least two raters were in agreement with the teacher’s rating).
6. Analyses of Hypotheses 1 and 2 were completed.
7. Results of the Imitative Finger Movement test subtest were reviewed and the subjects were divided into groups, depending on their scores.

Results

The data were processed with the SAS statistical package (SAS Institute, 1985). To test the hypothesis that children with handwriting difficulties will demonstrate less mature grips than their peers, a t test was performed to compare the two groups on the drawing task scores. The difference was significant ($t = 2.4, p = .02$), thus supporting this hypothesis. The maximum score obtainable was 5. The children with good handwriting ($n = 30$) had a mean score of 4.93 ($SD = 0.25$), and the children with poor handwriting ($n = 30$) had a mean score of 4.70 ($SD = 0.46$).

To test the hypothesis that among the children with handwriting difficulties, those with decreased proprioceptive-kinesthetic finger awareness will demonstrate less mature grips than those with normal proprioceptive-kinesthetic finger awareness, a t test was performed. The difference was significant ($t = -4.0, p < .001$), thus...

1Available from the Equipment Shop, Bedford, MA 01730.
supporting this hypothesis. Again, with the maximum score obtainable being 5, the children with good proprioception \((n = 18)\) had a mean score of 4.94 \((SD = 0.24)\), and the children with poor proprioception \((n = 12)\) had a mean score of 4.33 \((SD = 0.49)\).

To test the hypothesis that children with handwriting problems will show less preference for one hand than will children with no handwriting problems, a chi-square analysis was performed. The difference was significant \((\chi^2 = 4.04, df = 1, p = .04)\), thus supporting this hypothesis. Further analysis was done to determine whether there is a significant relationship between the development of a preferred hand and a mature grip (i.e., a grip score of 5). A chi-square analysis was performed for each group. No significant differences were found between hand preference and grip score for the group with good handwriting. A significant difference was found, however, between hand preference and grip score for the group with poor handwriting \((\chi^2 = 4.8, df = 1, p = .02)\), with the children with scores of less than 5 having almost equal representation of left- or right-hand preference and no hand preference.

**Discussion**

Handwriting is an important skill for school-aged children. Although handwriting difficulties have been observed in different populations of children, little is known about grip patterns in children with handwriting difficulties. The results of this study suggest that children with handwriting difficulties may demonstrate a lower grip score on a drawing task than children without handwriting problems. However, further analysis of the mean grip scores for children with poor handwriting, both with and without normal proprioceptive-kinesthetic feedback suggested by Benbow and observed by Levine et al. (1981) is the child’s tight grip of the pencil in order to provide some feedback from the joints as formations are executed.

The results of the present study suggest that proprioceptive-kinesthetic ability in children with poor grip should routinely be assessed to ascertain whether problems exist. Further study is needed to determine whether children with decreased proprioceptive-kinesthetic ability improve their grips with therapeutic intervention aimed at increasing this ability. Laszlo and Bairstow (1984) suggested that some children are not kinesthetically mature enough to master the complexities of writing until the age of 6 years. Follow-up of these children in second grade would provide information as to whether this development occurs or if therapeutic intervention is necessary.

The hypothesis that children with handwriting problems would show less preference for one hand than children without handwriting problems was supported. Only 1 child in the good handwriting group, as compared with 6 children in the poor handwriting group, did not have a preferred hand. Bensen and Geschwind (1968) suggested that a child who develops a hand preference early is likely to develop motor activities demanding coordination and fine dexterity earlier than a child who develops hand preference late. This is supported by Rosenbloom and Horton (1971), who proposed that a relationship exists between the development of a preferred hand and the development of the dynamic tripod grip. This proposition was documented in an earlier study (Schneck, 1989). This finding suggests that hand preference should be evaluated in children with low pencil-grip scores. If the child does not prefer one hand over the other, then, possibly, intervention should focus on the development of a preferred hand rather than on the refinement of grasp.

**Summary**

Sixty first-grade children, 30 with and 30 without handwriting difficulties, were tested for a comparison of pencil grips. The results suggest that children with handwriting difficulty may demonstrate a lower grip score on a draw-
ing task than children without handwriting problems. In addition, those children with poor handwriting and with decreased proprioceptive-kinesiathetic awareness demonstrated a lower grip score than did those children with poor handwriting and with good proprioceptive-kinesiathetic ability. The children with poor handwriting also showed less hand preference than did the children with good handwriting. These results suggest that proprioceptive-kinesiathetic ability and hand preference in children with poor grip should be assessed routinely to ascertain whether problems exist and to help establish treatment goals.

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