Midline Crossing Behavior in Children With Learning Disabilities

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The purpose was to compare children with and without learning disabilities (LD), ages 6–8 years, on midline crossing inhibition (MCI). Participants were 44 children (24 boys and 20 girls) in two groups (LD and non-LD), matched on age and gender. MCI was operationally defined as significantly slower contralateral movement when choice reaction time (CRT) and movement time (MT) performance were examined for ipsilateral, midline, and contralateral tasks with both upper and lower extremities. Participants completed 12 days of tests (30 trials each day) using a protocol developed by Eason and Surburg (1993). A 2 (Group) × 2 (Extremity) × 3 (Direction) repeated measures MANOVA revealed significant difference for each dependent variable. Children with LD displayed MCI, whereas children without LD did not.

The academic difficulties of children with learning disabilities (LD) have been studied extensively in a variety of disciplines (Ginsburg, 1997; O'Shea & O'Shea, 1997; Vogel, 1990). Unfortunately, motor difficulties of these individuals have not received the same amount of attention as their academic problems. Many children with LD display general motor deficits compared to their peers without LD (Bluechardt, Wiener, & Shephard, 1995; Bruininks & Bruininks, 1977; Brunt, Magill, & Eason, 1983; Haubenstricker, 1982; Rimmer & Kelly, 1989). Unless identified, these motor difficulties may persist throughout the school years. While many individuals with LD do exhibit motor difficulties, this is certainly not true for everyone. As reported by Miyahara (1994) after investigating gross motor performance of 55 children with LD, 24 of the 55 appeared free of motor problems.

Midline crossing refers to any motor action that results in looking, reaching, or stepping across the body’s midline. Eason and Surburg (1993) referred to difficulty in performing this movement as midline crossing inhibition (MCI). Research...
suggests that the frequency of spontaneous manual midline crossing advances from 4 to 8 years (Cermak, Quintero, & Cohen, 1980; Stilwell, 1987). Arendt, Maclean, and Baumeister (1988) found that midline crossing problems inhibit persons with certain types of motor dysfunction from successfully executing certain types of physical tasks. In addition, several studies have shown that individuals of various ages with developmental delays, such as mental retardation, display MCI (Eason & Surburg, 1993; Porretta, 1987; Surburg, Johnston, & Eason, 1994; Woodard, Surburg, & Lewis, 1998).

Interest in midline crossing problems can be traced back to research by Kephart (1970) and Ayres (1976)—leaders in the perceptual-motor and sensory integration remediation approaches, respectively. Kephart (1970) stated:

Young children often show hesitancy and reluctance to move the hand across the midline and display confusion when it is on the opposite side. Many slow-learning children will be seen to show the same hesitancy and confusion at a later age. (p. 91)

Perceptual-motor and sensory integration theories have evolved as developmental perspectives, mainly concerned with the ages at which behaviors naturally appear and the phenomena of developmental delays. Both theories support the principle of progression (i.e., that children naturally develop the ability to perform simple, easy tasks before harder, more complex ones). Kephart (1970) and other early observers of childhood behaviors noted that same-side (ipsilateral) hand movements were easier than those that required crossing the midline (contralateral), but scientific research did not address midline behavior until valid and reliable measures of crossing the midline were available.

For inclusion in the well known Southern California Sensory Integration Tests, Ayres (1976) developed the first widely used quantitative test for assessing an individual’s tendency to spontaneously cross the body’s midline. This measure, called the Space Visualization Contralateral Use Score (SVCU), is used to assess visual perception of form and space. The test is composed of a series of puzzles comprised by a formboard and two blocks. The formboard is placed at the midline, with one block slightly to the left and the other to the right. The SVCU score is the ratio between ipsilateral responses (picking up the left side block with the left hand, or vice versa) and contralateral responses (picking up the left side block with the right hand, or vice versa). Ayres (1976) based the validity and reliability of the SVCU on observations of 128 children with LD (ages 5–8, M age = 7 years, 6 months). The Space Visualization Test is still a section in Ayres’s (1989) Sensory Integration and Praxis Tests. While studying children with LD, Ayres found that the tendency to avoid crossing the midline was frequently accompanied by the inability to discriminate between the right and left sides of the body. Ayres suggested that these two behavioral dimensions might reflect a syndrome identified by diminished integration of the two sides of the body (bilateral integration). Cermak, Quintero, and Cohen (1980) added to Ayres’s information base by providing data from 150 children without LD. They reported that children ages 4–6 crossed the midline less frequently than those ages 7–8.

Cermak and Ayres (1984) evaluated whether using the SVCU could enable discrimination between children with and without LD. The SVCU was administered to 179 children with LD and 120 children without (ages 5–8). Cermak and Ayres (1984) reported that children with LD score significantly lower those without
LD. Multiple comparisons of each age level reveal a significant difference between groups. Compared to children without LD, those with LD score more poorly at ages 5, 6, and 7 but not 8.

Cermak and Ayres (1984) provided several possible reasons for why the older children with LD score better. Since crossing the midline appears to be a developmental skill, most children may have sufficiently matured by age 8 such that the deficit is not evident. Alternatively, some children with LD may have received special perceptual motor or sensory integrative services prior to the time of testing and have thus improved their ability to cross the midline of the body. Stilwell (1981) also used the SVCU to determine any differences in midline crossing behavior in 23 children with LD and 23 children without, ages 6–8. Compared to the investigation by Cermak and Ayres (1984), Stilwell found that the SVCU scores of the children with LD were significantly lower than those without LD.

Some adapted physical education textbooks highlight midline problems as important concerns to be addressed in physical education (Auxter, Pyfer, & Huettig, 1997; Sherrill, 1998). For example, students experiencing a hesitation or inability to cross the midline with the hand or foot may have difficulties with ball-handling skills and activities that require shifting weight and following through across the body, such as a backhand in tennis or softball throw. The lack of proper follow-through and weight shift illustrate midline crossing problems. Sherrill (1998, p. 334) includes crossing the midline tasks (e.g., throw a ball diagonally to a target on the far left, field a ball on the ground that is approaching the left foot) on her assessment instrument, Teaching-Testing Perceptual-Motor Tasks.

Eason and Surburg's (1993) method for detecting MCI has been used to assess MCI in various populations with developmental disabilities (Eason & Surburg, 1993; Surburg, Johnston, & Eason, 1994; Woodard et al., 1998). This assessment tool requires the individual to locate a stimulus, select a response, and then initiate and carry out the response. This method is based on an information-processing paradigm in which the traditional measurement index of motor ability is reaction time (Schmidt, 1988). The premise of this paradigm is that more complex tasks require more processing time than simpler ones (Henry & Rogers, 1960). Based on previous evidence (Eason & Surburg, 1993; Porretta, 1987; Surburg et al., 1994; Woodard et al., 1998), midline crossing (contralateral movement) represents a more complex task than ipsilateral movement and requires greater processing time.

Kerr and Hughes (1987) reported that the information-processing skills and motor abilities of children with LD were inferior to those without when performing Fitts’s reciprocal tapping task (Fitts, 1954). Children with LD may be unable to utilize their capabilities because of the inability to develop efficient strategies for task completion (Pressley, 1991; Torgesen, 1980). For children with LD, deficits have been noticed in selective attention (Wolfe, 1996), speed of processing (Watson & Willows, 1995), and problem solving (Ellis, 1993; Swanson, 1993).

Because efficient cognitive processing is thought to be required for successful motor skill performance (Schmidt, 1988), investigating processing skills may be an important factor for understanding the movement difficulties of children with LD. Brunt and Distefano (1983) reported that these children exhibit significant increases in reaction and movement times when coping with movement uncertainty during a running task. One reason for this is their inability to simultaneously attend to and process incoming stimuli while performing a skill. These data are consistent with the notion of processing deficits.
Unfortunately, little research on the movement problems of children with LD has been conducted using an information-processing framework. The general approach in studying movement difficulties of individuals with LD has been to describe performance, with little emphasis on understanding the processes underlying efficient movement. The relationship between LD and specific problems contributing to motor uncoordination has not been ascertained. The purpose of this study was to compare children with and without LD, ages 6–8, on MCI.

Method

Participants

Participants were 22 children with LD (12 boys and 10 girls, ages 6 years, 3 months to 8 years, 5 months) and 22 children without LD, matched on age and gender. The sampling design was purposive, meaning that criteria were used to select participants who are representative of a defined population. The criteria were based on the guidelines for Indiana (Indiana Council of Administrators of Special Education, 1986), which state that children displaying a severe discrepancy between intellectual ability, as measured by the Wechsler Intelligence Scale for Children-Revised (WISC-R), and performance on a standardized achievement test in one or more areas are classified as having a learning disability. A severe discrepancy is one of 1 SD or more. At the time of the study, none of the participants had been diagnosed as having attention deficit hyperactive disorder (ADHD).

Participants were recruited from five elementary schools within the same school corporation. All children were in integrated classes, and a majority were matched for age and gender within their respective classrooms. The non-LD and LD groups were matched according to birthdays. The birthday of a child in non-LD group fell either within 30 days before or after the birth date of a child in the LD group. In each group, there were five 6-year-olds, nine 7-year-olds, and eight 8-year-olds. Each child’s parent(s) received and signed a copy of the Human Consent Form. Neuromuscular disorders and visual and hearing impairments were determined through consultation with the children’s classroom teachers. If any one of these conditions were present, the child was excluded from the study.

Instrumentation

A modification of Eason and Surburg’s (1993) method for detecting MCI was used. Using this instrument, participants performed a choice reaction time (CRT) and movement time (MT) task with the upper and lower extremities. MCI was thus operationally defined as significantly slower contralateral movement when CRT and MT performance were examined for ipsilateral, midline, and contralateral tasks with both the upper and lower extremities. The rationale for this instrument is based upon an information-processing paradigm of which the basic measurement index is reaction time. This instrument has been used to assess MCI in various populations with developmental disabilities (Eason & Surburg, 1993; Surburg et al., 1994; Woodard et al., 1998) and older persons (Johnston-Lombardi & Surburg, 1995) but has not been used to assess individuals with LD.

Two identical pieces of apparatus were used, one for the upper extremity and one for the lower, with the size of each apparatus and its various components as the only differences. The upper extremity apparatus was the smaller of the two
(for a diagram, see Figure 1). Each apparatus consisted of a rectangular piece of plywood equipped with a microswitch release (touch) pad and three target stimuli pads. A red light emitting diode (LED) was positioned directly behind each target pad. An additional yellow LED was placed behind the middle red LED to identify a catch trial when illuminated. The touch pad was situated in the bottom center of the board, with one target pad directly in front, one to the right, and one to the left. All three were at an equal distance from the touch pad, with the right and left targets positioned at 45° angles.

The apparatus for the upper extremity was 60 × 70 cm and 1 cm thick. The touch pad and three target pads were 2.5 cm wide and constructed out of durable plastic mounted in a metal, circular frame. Distance between the touch pad and target pads was 33.5 cm. A red LED, positioned directly behind each target pad, was used to signal which one to press with the hand. Each LED was mounted in a 3 × 2 cm metal frame and placed 5 cm behind the target pad. The ipsilateral and contralateral LEDs were positioned at 45° angles to the touch pad so that the participant could have an equal view of all three LEDs. An additional yellow LED was placed 15 cm behind the middle target LED to identify a catch trial when illuminated. A warning signal (a buzzer housed in a 13 × 9 cm box resting on the top center of the board) notified the participant to initiate each trial.

The lower extremity apparatus was 60 × 90 cm and 1.5 cm thick. The touch pad and three target pads were 8 cm in diameter and constructed out of a durable, orange rubber material mounted on 8 × 10 cm rectangular metal plates. The LEDs

![Figure 1 — Midline crossing inhibition assessment apparatus.](image-url)
positioned behind the target pads were also mounted in 3 × 2 cm metal frames and placed 7 cm behind the target pad. The yellow LED representing catch trials was placed 20 cm behind the middle target LED. The warning signal was housed in a 15 × 10 cm box. All other characteristics were identical to the upper extremity apparatus.

Each participant was seated in a chair opposite the touch pad when performing upper extremity tasks. Lower extremity tasks were performed standing opposite the touch pad. Upon receiving a warning signal (i.e., the buzzer), participants were asked to press the touch pad with the hand or foot and remain in contact with it until LEDs activated, at which point participants moved the hand or foot as quickly as possible from the touch pad to the target pad of the illuminated LED. CRT was measured as the number of seconds from the moment the LED was activated to the time when the participant picked up the hand or foot from the touch pad. MT was the number of seconds elapsed between touch pad release and depression of the target pad.

For CRT and MT measurements, a portable laptop computer interfaced through a standard parallel printer port to the MCI apparatus was used. A basic computer program was written to generate randomized blocks of trials and stimulus presentations for each set of trials and to record all data.

Intraclass correlations were calculated to determine the reliability of the upper and lower extremity CRT and MT scores across testing days for both groups in the three testing directions. Intraclass correlations representing CRT for the lower extremity, CRT for the upper, MT for the lower, and MT for the upper were .93, .92, .92, and .91, respectively, for the children with LD. Intraclass correlations representing CRT for the lower extremity, CRT for the upper, MT for the lower, and MT for the upper were .97, .94, .83, and .91, respectively, for the children without LD.

Testing Procedure

After providing informed consent, each individual was tested individually by the first investigator. A testing session consisted of 30 trials, which included 9 midline movements, 9 ipsilateral movements, 9 contralateral movements, and 3 catch responses. Signals were presented randomly. During a catch trial the warning signal is given, but the stimulus is not presented; therefore, no movement should occur. Catch trials are used to prevent the participant from anticipating which stimulus will be presented.

To determine whether MCI was present, each participant completed 12 testing sessions on 12 different days (i.e., 360 trials): six sessions for the upper extremity (three preferred hand, three nonpreferred hand) and six for the lower (three preferred foot, three nonpreferred foot). Before testing, all participants engaged in two orientation sessions, one for the upper extremity apparatus and one for the lower, in which they were familiarized with the testing equipment and procedures.

Participants were positioned carefully for the test. During upper extremity testing, the participant was in a seated position with the touch pad directly in front of the sternum. The participant was positioned in a chair so that the trunk and thighs formed a 90° angle and the thighs and lower legs a 90° angle. The chair was adjusted so that the feet were always resting on the floor. During lower extremity
testing, the participant remained standing. Each participant stood on the board behind the touch pad with the iliac crest of the pelvis of the side being testing positioned directly behind the touch pad.

Trials were initiated by depressing the touch pad following the buzzer. Preparatory intervals, the period from a warning signal to the illumination of the stimulus, of 1.5, 3.0, or 4.5 s were then presented. The sequences of movement directions, catch trials, and preparatory intervals were based upon a stratified random procedure, which insured an equal number of different preparatory intervals, catch trials, and target stimuli pad usage. The interval between the red LED illumination and touch pad release constituted CRT. Depressing the target stimulus pad constituted task completion. The elapsed time from touch pad release (CRT) until depression of the target stimuli pad constituted MT. Testing sessions were approximately 15 min.

Data Analysis

Independent variables for this study included Group (children with LD, children without LD), Extremity (upper or lower), and Movement Direction (movement in the ipsilateral, contralateral, or midline direction). Dependent variables included CRT and MT. Intraclass correlations were calculated to determine the reliability of the upper and lower extremity CRT and MT scores across testing days for both groups (see results in Instrumentation section). Pearson product-moment correlations were calculated to ascertain whether a significant relationship existed between CRT and MT for each direction of movement (see Table 1). A 2 (Group) × 2 (Extremity) × 3 (Direction) repeated MANOVA was used to determine any significant main effects or interactions for MCI in children with and without LD. The approximate F associated with Wilks’ Lambda was used to determine significance (p < .05). Subsequent analysis of significant main effects and interactions for midline crossing effects on the dependent variables were done with univariate analyses of variance (ANOVA). The Student Newman Keuls’ method of multiple comparisons was used for additional postanalysis. A measure of strength of association, eta squared ($\eta^2$), was calculated to further interpret each significant effect (Tabachnick & Fidell, 1996). SPSS statistical analysis program was used for all data.

Table 1 Pearson Product Moment Correlation Coefficients Between Choice Reaction Time and Movement Time by Extremity for Movement Direction

<table>
<thead>
<tr>
<th></th>
<th>Children with LD</th>
<th>Children without LD</th>
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<tbody>
<tr>
<td></td>
<td>Contra-lateral</td>
<td>Ipsi-lateral</td>
</tr>
<tr>
<td>Upper extremity</td>
<td>.78*</td>
<td>.66*</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>.73*</td>
<td>.62*</td>
</tr>
</tbody>
</table>

Note. LD = learning disabilities. n = 22 in each group.
*p < .05.
Results

Pearson product-moment correlations were computed to ascertain whether significant relationships existed between the CRT and MT scores for each movement direction. All correlation coefficients were statistically significant (see Table 1). Due to the magnitude and significance of these relationships for both groups, a MANOVA was utilized to analyze the midline crossing data. Results of the 2 (Group) \( \times \) 2 (Extremity) \( \times \) 3 (Direction) MANOVA for CRT and MT included significant main effects for Group, \( F(2, 41) = 17.67, p < .05, \epsilon^2 = .46 \), Extremity, \( F(2, 41) = 22.35, p < .05, \epsilon^2 = .52 \), and Direction, \( F(4, 166) = 17.90, p < .05, \epsilon^2 = .51 \). A significant Group by Direction interaction, \( F(4, 166) = 9.65, p < .05, \epsilon^2 = .35 \), was also found.

Subsequent analysis of midline crossing effects on the dependent variables utilized a 2 (Group) \( \times \) 2 (Extremity) \( \times \) 3 (Direction) univariate ANOVA. Significant main effects for CRT were found for Group, \( F(1, 42) = 36.47, p < .05, \epsilon^2 = .46 \), Extremity, \( F(1, 42) = 33.66, p < .05, \epsilon^2 = .43 \), and Direction, \( F(2, 84) = 40.55, p < .05, \epsilon^2 = .39 \). A significant Group by Direction interaction, \( F(2, 84) = 20.82, p < .05, \epsilon^2 = .20 \), for CRT was also revealed. The result of the analysis for simple effects (Keppel, 1991) of this Group by Direction interaction was a significant difference for direction for children with LD, \( F(2, 84) = 59.36, p < .05, \epsilon^2 = .59 \). Student Newman Keuls’ method for multiple comparisons revealed that contralateral movements (crossing the midline) were initiated significantly slower than ipsilateral or midline movements for children with LD. The means and standard deviations for CRT are illustrated in Table 2.

Results of the ANOVA for MT scores revealed a significant main effect for Group, \( F(1, 42) = 24.02, p < .05, \epsilon^2 = .36 \), and a significant Extremity by Direction interaction, \( F(2, 84) = 24.96, p < .05, \epsilon^2 = .37 \). Further analysis for simple effects of the interaction showed a significant difference in MT for direction in the upper extremity, \( F(2, 168) = 11.63, p < .05, \epsilon^2 = .10 \), as well as in the lower ones, \( F(2, 168) = 16.20, p < .05, \epsilon^2 = .14 \). Additional analysis utilizing Student Newman Keuls’ method provided evidence that the upper extremity contralateral (crossing the midline) MT was significantly slower than ipsilateral and midline MT for the children with LD. For the lower extremity, MT for ipsilateral movements was significantly slower than for contralateral and midline movements in both groups. In addition, MT for children with LD was significantly slower than those for children without LD. Table 2 presents upper and lower extremity MT means and standard deviations.

Discussion

The purpose of this study was to compare children with and without LD, ages 6–8, on MCI. For children with LD, CRT associated with contralateral movement (crossing the midline) was significantly slower than CRT for ipsilateral and midline movements. This was true for upper and lower extremity movements. CRT for contralateral, midline, and ipsilateral movements were not significantly different for children without LD.

These findings support previous studies of midline crossing behavior in children with LD. Ayres (1976) reported a tendency of children with LD, ages 5–8, to avoid crossing the midline. Administering Ayres’s (1976) Space Visualization test,
Table 2  Choice Reaction Time and Movement Time for Children With and Without LD

<table>
<thead>
<tr>
<th></th>
<th>Contralateral</th>
<th>Midline</th>
<th>Ipsilateral</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td>Choice reaction time (s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With LD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper extremity</td>
<td>0.84*</td>
<td>0.58</td>
<td>0.72</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>1.01*</td>
<td>0.60</td>
<td>0.87</td>
</tr>
<tr>
<td>Without LD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper extremity</td>
<td>0.53</td>
<td>0.19</td>
<td>0.50</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>0.62</td>
<td>0.17</td>
<td>0.59</td>
</tr>
<tr>
<td>Movement time (s)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>With LD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper extremity</td>
<td>0.46*</td>
<td>0.32</td>
<td>0.44</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>0.42</td>
<td>0.38</td>
<td>0.42</td>
</tr>
<tr>
<td>Without LD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper extremity</td>
<td>0.29</td>
<td>0.13</td>
<td>0.28</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>0.25</td>
<td>0.17</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Note. LD = learning disabilities. Choice reaction time was the interval between the LED illumination and removal of body part from the touch pad. Movement time was the interval between removal of the body part from the touch pad and depression of the target stimulus pad.

*p < .05, significantly slower.

Stilwell (1981) and Cermak and Ayres (1984) provided evidence of midline crossing problems for children ages 6–8 and 5–7, respectively. However, 8-year-old children did not display midline crossing problems (Cermak & Ayres, 1984).

In the current study, 22 children with LD, ages 6–8, exhibited midline crossing deficits in their upper and lower extremities. The investigations mentioned earlier utilized only the upper extremities. The assessment method (Eason & Surburg, 1993) used in this study included a temporal component, whereas the Space Visualization Test did not. In the present study, an individual was required to plan and initiate a midline crossing response under temporal constraints. This entailed locating a stimulus, selecting a response, performing response programming, and then initiating the response as quickly as possible.

The assessment method used in the current study is based on an information-processing paradigm in which the traditional measurement index of motor ability is reaction time (Schmidt, 1988). The underlying premise of this paradigm is that more complex tasks require more processing time than simpler ones. Results of the current study reinforce the view that processing skills may also be an important factor contributing to the movement difficulties experienced by many children with LD (Brunt & Distefano, 1983; Kerr & Hughes, 1987; Schmidt, 1988).
In terms of MT, children with LD were slower than those without. The ability to extend the hand or foot to the contralateral side of the body allows an individual to perform various types of manual and postural control tasks. The ability to guide an extremity to targets in the contralateral space of the body is essential to bilateral coordination (Provine & Westerman, 1979). Before this occurs, each side of the body functions in relative isolation. The skill may become less consistent when the task becomes more complex.

Fitt’s Law (1954) implies an inverse relationship between movement difficulty and the speed at which it can be performed (Schmidt, 1988). The premise is that there is a speed-accuracy tradeoff as increasing difficulty decreases speed. MT results in the present study may also be addressed in the context of task complexity. Henry and Rogers (1960) stated that reaction and movement times are indexes of a task’s complexity within a “memory drum theory” of programming for learning and performing movement tasks. They hypothesized that as an activity becomes more complex, more time is needed to coordinate increased neurological complexity. The present findings indicate that contralateral movements of the upper extremity may be more complex than ipsilateral and midline ones. This was not true for the lower extremity, in which MT associated with ipsilateral movements was slower than contralateral and midline actions. Midline crossing may not have provided additional complexity when the lower extremity was being used. No studies on the lower extremity MT of children with or without LD, ages 6–8, are available to verify these findings.

The differences in MT between the two groups could possibly be attributed to associated movements. Lazarus (1994) investigated the ability of children with LD to inhibit associated, or extraneous, movements. Children with LD generally do not perform as well as their peers without LD on selective and sustained attention tasks (Pihl & Niauro, 1982; Wolfe, 1996). Lazarus (1994) hypothesized that children with LD would have difficulty inhibiting associated movement even when encouraged to do so. When performing a unimanual force production task with performance feedback, children without LD were able to inhibit associated movements while regulating force production. The children with LD, however, could not decrease associated movements. In the present study, the slower MT for children with and without LD might be related to associated movements.

In summary, children with LD displayed MCI in both the upper and lower extremities, whereas those without LD did not. Difficulty or a reluctance to cross the midline may be a factor that hinders motor skill learning and performance. Not all children with LD exhibit motor deficits, but many do (Lazarus, 1990; Miyahara, 1994). Before an appropriate physical education program can be developed, motor skill assessment is necessary to determine the child’s strengths and weaknesses. Given the findings of the current study, midline crossing behavior should be a consideration when evaluating motor behavior of children with LD.

References


