Motor Proficiency of Boys With Attention Deficit Hyperactivity Disorder and Boys With Learning Disabilities

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The motor proficiency of 56 boys with attention deficit hyperactivity disorder (ADHD) was compared with that of 56 boys with learning disabilities (LD); both groups were divided into two age groups, 7 to 8 years and 9 to 12 years. Boys with ADHD were taking Ritalin and attending public schools. Boys with LD were medication-free and attending private schools for LD. The Bruininks–Oseretsky Test of Motor Proficiency–Long Form (BOTMP–LF) was used to measure balance, bilateral coordination, strength, upper limb coordination, response speed, visual–motor coordination, and upper limb speed and dexterity. MANOVA revealed significant main effects for condition and age. Subsequent univariate ANOVAs revealed (a) expected age differences on all but one item and (b) significantly poorer performance for boys with ADHD than boys with LD on all variables except balance, upper limb coordination, and response speed.

The impact of attention deficit hyperactivity disorder (ADHD) on the academic, social, and psychomotor performance of children has been a source of concern for parents and educators for several decades. It is estimated that 3% to 20% of school-age children exhibit ADHD behaviors (Cantwell, 1996; Shaywitz & Shaywitz, 1991). ADHD is often associated with and sometimes confused with learning disabilities (LD) and developmental coordination disorder (DCD) (Cantell, Smyth, & Abonen, 1994; Hoare, 1994; Lazarus, 1990, 1994; Missiuna, 1994; Wright & Sugden, 1996). From 15% to 42% of children with LD may also exhibit ADHD behaviors (Holobrow & Berry, 1986; Shaywitz, Fletcher, & Shaywitz, 1995; Silver, 1981). Although the American Psychiatric Association (1994) defines each of these conditions as a distinct category, federal legislation does not, which often complicates programming in the school setting. Difficulty in distinguishing between ADHD, LD, and DCD has increased the need for research on all aspects of these three conditions; however, this study is limited to a comparison of ADHD and LD as defined by DSM-IV (American Psychiatric Association, 1994).

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The motor behavior of children with only ADHD has received little attention (Harvey & Reid, 1997). Moreover, in research on the motoric profiles of children with LD and the identifiable subgroups of this disability, researchers have not divided their participants on the basis of presence or absence of ADHD (Churton, 1989; Lazarus, 1990, 1994; Miyahara, 1994).

Although all children with LD do not display motor problems, many do (Bruininks & Bruininks, 1977; Miyahara, Mobs, & Doll-Tepper, 1995; Schaffer, Law, Polatajko, & Miller, 1989; Sherrill & Pyfer, 1985). Haubenstricker (1982) contended that many children with LD display visual and spatial motor difficulties and thus can be considered “clumsy” or “awkward.” Cermak, Trimble, Coryell, and Drake (1990) established that male adolescents with LD perform more poorly than males without LD on tasks of bilateral coordination. In studies by Lazarus (1990), children with LD were divided into two distinct subtypes. One group demonstrated subtle motor difficulties but were language impaired primarily in information processing and appeared to prefer visual learning. The second identifiable group had apparent motor problems and clumsiness. These children showed more overflow movements, had difficulty with visual–motor tasks, and were inferior to children without LD in spatial orientation and tasks requiring motor planning and sequencing of motor acts (Lazarus, 1990).

Harvey and Reid (1997) examined fundamental gross motor skills and fitness conditions of 19 children, 17 boys and 2 girls, with ADHD. The Test of Gross Motor Development (TGMD, Ulrich, 1985) was used to examine performance on 12 test items subdivided into two skill areas: locomotor skills (run, gallop, hop, leap, horizontal jump, skip, and slide) and object control skills (two-hand strike, stationary bounce, catch, kick, and overhand throw). Fitness conditions were assessed by measuring height, weight, body mass index, body composition skinfolds, sit and reach, total grip strength, \( \text{VO}_2 \), push-ups, sit-ups, and shuttle run. Harvey and Reid (1997) concluded that children with ADHD are below average in fundamental gross motor performance and fitness. Findings were somewhat limited in this preliminary study by the small sample size, the lack of a control group, and no distinction as to whether participants with ADHD also had LD.

The focus of most research on ADHD is primarily on difficulties in perceptual and fine motor skills and the effects of medication on performance. The need to develop a comprehensive motor profile is often ignored. Luk, Leung, and Yuen (1991) investigated 61 boys, ages 6 to 12 years, with a diagnosis of hyperkinetic syndrome. Several measures were examined: (a) teacher and parent ratings, (b) neurological examination, (c) psychiatric interview, (d) tests of clumsiness, (e) Weschler Intelligence Scale for Children (1983), (f) paper-and-pencil attention test, (g) Continuous Performance Test (1965), (h) Porteus Maze Test (1947), and (i) Matching Familiar Figures Test (1978). The four tests of clumsiness by Gubbay (1975) were described as putting objects in a posting box; rolling a ball with a foot; threading 10 beads; and throwing a tennis ball in the air, clapping, and catching the ball. Scores were recorded for the amount of time in seconds for the first three tasks; the fourth task was scored by levels, a higher throw being better. All measures were individually assessed and participants were then further divided into groups according to whether they exhibited hyperactivity in the clinical setting \((n = 43)\) or not \((n = 18)\). Comparisons of the two groups showed significantly
poorer performance \((p < .05)\) by participants who exhibited hyperactivity in the clinical setting in areas of general intelligence, cognitive styles, attention, minor neurological deficits, and motor clumsiness.

Werry, Elkind, and Reeves (1987) compared children aged 5 to 13 years who had ADHD; gender was not reported. The sample included 39 participants classified as ADHD, 21 participants classified as anxious (ANX), 35 participants classified as conduct disordered (CD), and 95 matched controls without disabilities. Comparisons were made on measures of arousal, activity level, impulsivity, cognition, and motor coordination. The latter was assessed by maze and hole tests adapted from the Wisconsin Children’s Neuropsychological Battery (1963) and the pursuit rotor developed by Eysenck (1969). A comparison of participants across diagnosis groups (ADHD, ANX, CD) showed no significant differences \((p < .05)\) in motor coordination. However, when compared to matched controls without disabilities, participants with ADHD were significantly inferior in timed tasks of motor coordination, specifically the maze test and pursuit rotor.

Research on the effects of stimulant medication on learning in children with ADHD is well documented but has primarily focused on its beneficial effects in the classroom (Douglas, Barr, O’Neill, & Britton, 1988; Gadow, 1985; Pelham, 1983; Pelham, Bender, Caddell, Booth, & Moorer, 1985; Swanson et al., 1993; Swanson, Cantwell, Learner, McBurnett, & Hanna, 1991). Studies focusing on motor performance are much more limited. Hefley and Gorman (1986) reported that children without disabilities performed significantly better than both nonmedicated and medicated children with hyperactivity on 8 of 10 motor learning tasks. All items were measures of tracking, manual dexterity, response, and reaction time. Knights and Hinton (1969) examined the effects of medication on the motor coordination (maze, holes, pegboard) of 40 children (ages 8 to 15) with minimal brain dysfunction (MBD) with hyperactivity. Findings indicated that the ability to maintain attention, rather than motor speed or control, was most influenced by the medication (methylphenidate). These findings were supported by Brandon, Eason, and Smith (1986), who proposed that children with ADHD who are not on medication tend to lack the ability to pay attention to the relevant cues in performance situations.

Wade (1976) compared a group of 12 children without disabilities and 12 children with ADHD with and without medication (Ritalin) on maintenance of equilibrium on a 3-ft by 3-ft square balance board that was mounted on a central axis that deviated \(\pm10^\circ\) from horizontal. Results indicated that participants with ADHD taking the medication were more consistent in their balancing abilities than those taking the placebo. Participants with ADHD who took medication significantly improved their performance over the 30 trials. This finding was related to increased ability to attend to knowledge of results, which in turn improved balance board performance.

Programming for children with ADHD increasingly relies on research (Bishop & Beyer, 1995; Decker & Voege, 1992; Jansma & French, 1994; Sherrill, 1998). However, much research fails to differentiate between ADHD and LD conditions. To strengthen the knowledge base, investigators must identify and then evaluate discrete samples of children with only one diagnosis, either LD or ADHD. The purpose of this study was to compare boys with ADHD and boys with LD on motor proficiency.
Method

Participants

Participants were 56 boys with ADHD who were taking Ritalin and 56 boys with LD who were not taking medication, divided equally into two age groups (ages 7 and 8 and ages 9 to 12). The sampling design was purposive, meaning criteria were used to obtain representative samples of the ADHD and LD diagnostic categories. Boys with ADHD were selected first; then boys with LD were located who could be matched within a 6-month chronological age range of the participants with ADHD.

The 56 boys with ADHD were drawn from children taking Ritalin and attending public schools who had been jointly referred by teachers and parents to an interdisciplinary clinic at a university for further testing and programming. An interdisciplinary team of university faculty members, led by the clinic physician, verified that each participant clearly met the DSM-IV (American Psychiatric Association, 1994) criteria for ADHD and indicated no evidence of learning disabilities or sensory or orthopedic impairments. Verification that participants met DSM-IV criteria was based on independent testing by the physician and faculty members, all of whom had doctoral degrees, and on study of teacher rating forms, parent interviews, and questionnaires.

The 56 boys with LD were drawn from children attending two private schools for LD. Eligibility requirements for acceptance into these schools vary, so principals were requested to identify students for the present study who met the federal guidelines for diagnosis as having specific learning disabilities. Specifically, all study participants had an IQ of 70 or higher and a severe discrepancy between intellectual ability and academic achievement in one or more areas. Severe discrepancy was defined as a score that is 1.5 or more standard deviations below average on a standardized academic achievement test.

Measures

The Bruininks-Oseretsky Test of Motor Proficiency–Long Form (BOTMP-LF) was used. An individually administered test for ages 4.6 to 14.6 years, BOTMP-LF is designed to provide a comprehensive index of motor proficiency including separate measures of gross and fine motor tasks (Bruininks, 1978). The BOTMP-LF is commonly used in the physical education environment as an assessment tool. The reported intrarater reliability coefficients for the long form are .98 and .90, and construct validity is confirmed (Bruininks, 1977; Verderber & Payne, 1987). The BOTMP-LF assesses eight variables with 46 separate tasks. For this study, the running speed and agility subtest was omitted because of limited space in a number of the testing environments. The seven subtests used were balance, bilateral coordination, strength, upper limb coordination, response speed, visual–motor control, and upper limb speed and dexterity.

Design and Procedure

The BOTMP-LF was administered by experienced adapted physical education specialists who had completed a graduate level adapted physical education
ADHD and LD

assessment course taught by a professor widely known to be an expert in BOTMP concerns. In addition to demonstrating mastery of the BOTMP examiner’s manual (Bruininks, 1978) by written test scores, these specialists had also accumulated several hours of supervised practice in BOTMP–LF test administration.

Boys with ADHD were administered the BOTMP–LF at the university clinic by one of six individuals specially trained by this professor, who verified that assessment data were valid and reliable and should be entered into the boys’ permanent clinic files. In addition to personally reviewing test scores, this professor spot-checked some assessments by two-way mirror.

Boys with LD were administered the BOTMP–LF at their respective schools by one test administrator, who had been trained by the same professor as the other test administrators and had the same background of considerable supervised practice. Participants were assessed individually between the times of 9 a.m. and 12 p.m.

Procedures for test administration were kept constant for the boys with ADHD and the boys with LD, except for location of testing, time of day, and test administrator. Because all test administrators had been trained by the same professor, who ensured that each met mastery standards, intertester reliability (objectivity) was assumed to be high.

Statistics were calculated using the Statistical Package for Social Sciences (1997). Initially, a multivariate analysis of variance (MANOVA) was applied to test the hypotheses of (a) no significant difference between age groups, (b) no significant difference between conditions, and (c) no significant interaction. After the hypotheses for age groups and conditions concerning the seven combined dependent variables were rejected, univariate 2 X 2 (Age X Condition) ANOVAs were computed for each of the seven dependent variables to find specifically where the differences lay.

Results

The initial MANOVA revealed that the combined dependent variables were significantly affected by both condition, \( F(7, 102) = 10.96, p < .001 \), and age, \( F(7, 102) = 5.05, p < .001 \). However, no multivariate interaction was found, \( F(7, 102) = .37, p = .374 \). Subsequent univariate 2 X 2 ANOVAs revealed that the older group performed significantly better on six of the motor proficiency variables, as was expected, and the younger group performed better on one motor proficiency variable (visual–motor control), which was not expected. Effect sizes for the significant age group comparisons were .82, .63, .80, .86, .75, and .57, respectively. These effect sizes can be interpreted as moderate to large.

The subsequent univariate 2 X 2 ANOVAs indicated that males with ADHD had significantly poorer performance than males with LD on four variables (bilateral coordination, strength, visual–motor coordination, and upper limb speed and dexterity) and that the two groups were statistically equal on three variables (balance, upper limb coordination, and response speed). Effect size for differences in bilateral coordination and upper limb speed and dexterity were .55 and .72. Effect size for differences in strength and visual–motor coordination were 1.10 and 1.25.

Means and standard deviations for each of the seven variables are presented in Table 1. Also presented in Table 1 are the probability and effect size values for each of the statistically significant comparisons.
Table 1  Performance on Bruininks–Oseretsky Test of Motor Proficiency by Age and Condition

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Ages 7–8</th>
<th>Ages 9–12</th>
<th>Effect size</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Balance</td>
<td>20.39</td>
<td>5.29</td>
<td>24.18</td>
</tr>
<tr>
<td>Bilateral coordination</td>
<td>8.06</td>
<td>3.27</td>
<td>10.06</td>
</tr>
<tr>
<td>Strength</td>
<td>16.96</td>
<td>6.12</td>
<td>21.50</td>
</tr>
<tr>
<td>Upper limb coordination</td>
<td>13.18</td>
<td>4.13</td>
<td>16.39</td>
</tr>
<tr>
<td>Response speed</td>
<td>5.89</td>
<td>3.20</td>
<td>8.27</td>
</tr>
<tr>
<td>Visual–motor control</td>
<td>18.34</td>
<td>4.64</td>
<td>19.91</td>
</tr>
<tr>
<td>Upper limb speed</td>
<td>33.48</td>
<td>8.07</td>
<td>37.88</td>
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<tr>
<td>and dexterity</td>
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<table>
<thead>
<tr>
<th>ADHD</th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
<th>p</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>22.59</td>
<td>5.08</td>
<td>21.98</td>
<td>4.08</td>
<td>.49</td>
<td>—</td>
</tr>
<tr>
<td>Bilateral coordination</td>
<td>8.06</td>
<td>4.21</td>
<td>10.06</td>
<td>2.14</td>
<td>.001*</td>
<td>.55</td>
</tr>
<tr>
<td>Strength</td>
<td>16.13</td>
<td>5.98</td>
<td>22.34</td>
<td>5.28</td>
<td>.001*</td>
<td>1.10</td>
</tr>
<tr>
<td>Upper limb coordination</td>
<td>14.62</td>
<td>4.08</td>
<td>14.95</td>
<td>3.34</td>
<td>.65</td>
<td>—</td>
</tr>
<tr>
<td>Response speed</td>
<td>6.27</td>
<td>3.61</td>
<td>7.89</td>
<td>2.80</td>
<td>.009</td>
<td>—</td>
</tr>
<tr>
<td>Visual–motor control</td>
<td>6.27</td>
<td>3.70</td>
<td>21.75</td>
<td>4.70</td>
<td>.001*</td>
<td>1.25</td>
</tr>
<tr>
<td>Upper limb speed</td>
<td>32.84</td>
<td>9.03</td>
<td>38.52</td>
<td>6.46</td>
<td>.001*</td>
<td>.72</td>
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<td>and dexterity</td>
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*Note.* n = 28 for each ADHD and LD group. df for all 2 X 2 ANOVAs was 1, 108.

Discussion

The purpose was to determine if there were differences in motor proficiency scores that warranted different approaches for addressing the physical education movement needs of boys with ADHD and boys with LD. The overall MANOVA of the main effect of condition did, in fact, reveal a significant difference between boys with ADHD and boys with LD.

Boys with LD performed significantly better than boys with ADHD in the areas of bilateral coordination, strength, visual–motor control, and upper limb speed and dexterity. The poorer performance by children with ADHD supports research findings that performance in fine motor and timed tasks of motor coordination is significantly inferior in participants with ADHD when compared to controls without disabilities and nonmedicated children with ADHD (Conners, Rothschild,
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Eisenberg, Stone-Schwartz, & Robinson, 1968; Douglas, 1972, 1980; Hefley & Gorman, 1986; Knights & Hinton, 1969; Palkes, Stewart, & Kahana, 1968; Werry et al., 1987). The results also support findings that children with ADHD have more difficulty performing visual–motor tasks (Connors & Delamater, 1980; Conrad, Dworkin, Shai, Tobiessen, 1971; Korkman & Pesonen, 1994; Sandberg, Rutter, & Taylor, 1978; Zentall & Leib, 1985). Shaywitz and Shaywitz (1987) partially explained these deficiencies by suggesting that performance by children with ADHD is impacted by the inability to control motor activity, determine relevant external stimuli, sustain attention, and reflect before acting. Researchers have noted that attentional ability and information processing are significantly poorer in some children with ADHD even when on medication (August & Garfinkel, 1990; Tarnowski, Prinz, & Nay, 1986).

This interpretation appears to be supported in the present study. In all of the subtests in which the scores of the boys with ADHD were significantly lower, a high degree of attention and motor planning are required because they are novel tasks (Magill, 1998; Rose, 1997).

Analysis of the balance and upper limb coordination scores revealed no significant differences between boys with ADHD and boys with LD. Little research has examined the direct differences in balancing ability and upper limb coordination of the two conditions defined in the present study. However, difficulties in balance have often been associated with children with LD (Gorman & Pyfer, 1981; Haubenstricker, 1982; Horak Shumway-Cook, & Crowe, 1988) and with ADHD (Wade, 1976). The subtests of balance and upper limb coordination, on which the two groups performed similarly, contain tasks such as walking a balance beam, catching, and throwing, which are more frequently incorporated into physical education programs.

The similarity in performance of males with the two conditions on response speed was expected, because it is documented that response speed can be a deficit in children with LD and children with ADHD (Hefley & Gorman, 1986; Kerr & Hughes, 1987). Although researchers have investigated the effect of stimulant medication and found improved reaction time (Cohen, Douglas, & Morgenstern, 1971; Porges, Walter, Korb, & Sprague, 1975), the children taking medication in the present study were similar to those not taking medication.

Luk et al. (1991) revealed that participants who exhibited hyperactivity but were not diagnosed with or without LD in the clinical setting had poorer performance on a fine motor task related to upper limb coordination. In the present study, which did discriminate between LD and ADHD, balance, upper limb coordination, and response speed scores were not significantly different for the two conditions. Harvey and Reid (1997) indicated that boys and girls, ages 7 to 12, performed poorly on TGMD items, several of which depend on upper limb coordination and balance.

An additional consideration is the differences in within-group scores. The standard deviations were higher for boys with ADHD than for boys with LD in all areas except visual–motor control. This may indicate that these boys with ADHD were a more heterogeneous group or that the use of six testers with the ADHD group, as compared to one tester for the LD group, may have resulted in more within-group differences. Another factor that may have affected heterogeneity was that children with ADHD were tested at various times throughout the day, whereas children with LD were tested only in the morning. Further research is needed on these variables.
References

previous sport instruction and experience into coordination. Based on current, individualized training that lacks medication, one day, and groups appear weak in these areas. Physical education programs should be

Case

Based on results, boys with ADHD who take Ritalin and attend public schools

Conclusion

Tasks for longer periods of time and become more skilled moves.

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