Predicting School Adjustment from Motor Abilities in Kindergarten

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The present study assessed the relations between basic motor abilities in kindergarten and scholastic, social, and emotional adaptation in the transition to formal schooling. Seventy-one five-year-old kindergarten children were administered a battery of standard assessments of basic motor functions. A year later, children's adjustment to school was assessed *via* a series of questionnaires completed by the children and their class teachers. The results indicate that in addition to the already documented association between visual–motor integration and academic achievement, other motor functions show significant predictive value to both scholastic adaptation and social and emotional adjustment to school. The results further suggest a better prediction of scholastic adaptation and level of disruptive behaviour in school when using an aggregate measure of children's ability in various motor domains than when using assessments of singular motor functions. It is concluded that good motor ability may serve as a buffer to the normative challenges presented to children in the transition to school. In contrast, poor motor ability emerges as a vulnerability factor in the transition to formal schooling.   Copyright © 2007 John Wiley & Sons, Ltd.

Key words: school adjustment; motor ability; social adjustment; scholastic adjustment; transition to school

INTRODUCTION

The transition to formal schooling is one of the most significant changes in children's life (Belsky & MacKinnon, 1994; Pianta, Cox, Taylor, & Early, 1999; Stipek & Byler, 1997). Compared with preschool settings, school forms a dramatically different environment for children (Rimm-Kaufman & Pianta, 2000). The curriculum of formal schooling is typically more goal oriented in

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terms of literacy, numeracy, and socialization, in contrast with the less formally stated goals of the preschool environment (Haines, Fowler, Schwartz, Kottwitz, & Rosenhoetter, 1989). In addition, increased child-to-teacher ratios in schools change the nature of teacher–child interaction. While teacher–child interaction in preschool is usually characterized by personal care, warmth, and social and emotional support, in grade school, teacher–child interaction becomes more formal and academically oriented (Howes, 2000; Pianta & Stuhlman, 2004; Simpson, Cristo, & Gibbons, 1993). These changes impose new demands on children, such as greater independence from adults, autonomous adherence to routine, and being alert and active for longer periods of time (Nelson, 2004). The combination of new challenges and reduced social and emotional support can turn the transition to formal schooling into a demanding and stressful period.

In the transition to school, children are required to adjust both scholastically and socio-emotionally. Scholastic adjustment concerns a child's ability to meet academic demands, to be attentive, to participate in class activities, and become an independent student. Social and emotional adjustments refer to a child's ability to establish meaningful and positive relationships with teachers and peers, and feel emotionally secure. Children's sense of social comfort and security in school influence their ability to concentrate on academic challenges (Buhs & Ladd, 2001; Ladd, 1990; Ladd, Birch, & Buhs, 1999; Ladd, Kochenderfer, & Coleman, 1996; Ladd & Price, 1987; Risi, Gerhardstein, & Kinster, 2003), and vice versa, children's academic performance affect their sense of self-worth and future social and emotional adjustment (Chen, Rubin, & Li, 1997).

Various factors have been suggested as sources of influence on children's adjustment to school. Among these are child characteristics (e.g. cognitive readiness, language abilities, visual–motor coordination, temperament; for a review see Rimm-Kaufman & Pianta, 2000); family relationships (e.g. Alexander & Entwisle, 1988; Alexander, Entwisle, & Olson, 2001); school settings (e.g. school atmosphere, teachers-to-children ratio, number of familiar peers at school entrance, teacher–child relationship, Birch & Ladd, 1997; Goodman, Brumley, Schwartz, & Purcell, 1993); and general background factors (e.g. gender, ethnicity, socioeconomic status, McDermott, 1995; McWayne, Fantuzzo, & McDermott, 2004).

Among the child characteristics associated with school adjustment, visual–motor ability has been suggested as a significant predictor of academic adaptation (Carlton & Winsler, 1999; Kurdek & Sinclair, 2000). Visual–motor ability is a skill that requires good integration between fine motor accuracy and visual–spatial perception (Case-Smith, 1998). These skills are typically measured with the Developmental Test of Visual–Motor Integration (VMI, Beery, 1989), that contains separate assessments of fine motor accuracy, visual–spatial perception, and their integration. Indeed, Mantzicopoulos, Morrison, Hinshaw, and Carte (1989) found that children who were retained in kindergarten scored significantly lower on the VMI than their non-retained peers. In the same vein, Simner (1989) found that printing errors in pre-kindergarten children remained stable over time and predicted their academic performance in school. It is not surprising that visual–motor coordination is predictive of academic performance since it is estimated that anywhere between 30% and 60% of the school day is devoted to fine motor activities such as writing, cutting, and colouring (McHale & Cermak, 1992). Thus, a substantial part of a child's required academic activity at school is dependent upon efficient visual–motor integration (e.g. Levine, 1987;

Schoemaker & Kalverboer, 1994; Smits-Engelsman, Niemeijer, & Van-Galen, 2001; Sortor & Kulp, 2003; Taylor, 1999; Tseng & Chow, 2000). Although the logic of assessing visual–motor integration in relation to school readiness is clear, it is surprising that other basic motor faculties, which are also essential to the execution of goal directed action in school, such as muscle tone and motor planning, have been neglected in this context.

Muscle tone is essential for posture control and for producing motor action. In class, children need to maintain static postures as well as freely move in and out of postural positions (Lane, 2002). Children with low muscle tone typically find it difficult to retain motor action for prolonged periods, and frequently complain of fatigue, and show limited speed during the performance of common school tasks such as writing and sitting (Smits-Engelsman *et al.*, 2001).

Motor planning involves cognitive processes responsible for selecting and programming an appropriate motor response (Wilson, Maruff, Ives, & Currie, 2001). The motor planning of any behaviour, including basic school tasks, involves generating an idea of the motor task to be performed, sequencing this idea, and executing the sequence in an efficient way. If these complex neurobehavioural processes are successful, the child is able to produce adaptive behaviours and goal-directed actions that meet schools' academic demands. In contrast, poor motor planning may adversely affect and limit a child's behaviour in school. Children characterized by poor motor planning ability often fail to participate in academic activities (e.g. Ayres, 1980; Henderson & Hall, 1982; Schaaf, Merril, & Kinsella, 1987). Motor planning is dependent upon effective functioning of the kinesthetic system, which provides awareness of body position and movement in space. The kinesthetic sense arises from neural feedback provided by joints, tendons, and muscle receptors. Kinesthetic functions are typically indexed by the ability to accurately perceive and replicate different body positions (imitation of postures), and by the ability to accurately replicate rehearsed motor movements.

In addition to the reported associations between motor functions and academic achievement, similarly potent associations may emerge between motor functions and social and emotional adjustment to school. Because of the fundamental role of various motor functions in performing even the most basic school requirements, children experiencing motor difficulties might fail to participate in social activities in the school setting (Bar-Haim & Bart, 2006). Such children move slowly and fearfully and may avoid the gross motor movement required for important school activities such as social play and physical education classes (e.g. Parham & Fazio, 1997). For example, Smyth and Anderson (2000) found that 6- to 10-year-olds with developmental coordination disorder (DCD; a childhood disorder characterized by poor coordination and clumsiness), spent more time alone during school playground activity compared with normally coordinated children. In addition, various studies have demonstrated that poor motor coordination is associated with low self-esteem and loneliness in primary-school children (Piek, Dworcan, Barrett, & Coleman, 2000; Schoemaker & Kalverboer, 1994; Skinner & Piek, 2001). However, the associations between motor abilities and social and emotional adjustment have received very little research attention and only in clinical populations (Dewey, Kaplan, Crawford, & Wilson, 2002; Smyth & Anderson, 2000).

Therefore, the goals of the present study were twofold. First, we set out to assess the correlations between basic motor abilities in kindergarten and scholastic adaptation to first grade[1] in a normative sample of children. We specifically assessed the relative contribution of muscle tone and motor planning

abilities (kinesthesia and imitation of postures) to the prediction of scholastic adaptation, in addition to the typically tested visual–motor integration components. Second, we assessed whether motor abilities as measured in kindergarten predict social and emotional adjustment to first grade. Finally, because several studies reported gender differences in children's motor activity in school (e.g. Blatchford, Baines, & Pellegrini, 2003; Pellegrini, Blatchford, Kato, & Baines, 2004) we assessed whether motor abilities in kindergarten were differentially associated with adjustment to formal schooling for boys and girls.

METHODS

Participants

Eighty-eight children (53 girls, 35 boys) from seven randomly selected public kindergarten classes were recruited for the study. Children's mean age was 5.83 years (S.D. = 0.46; Range=5.04–6.36 years). Because age-related norms for several of the motor measures used in the study were available starting from five years of age, an age of five years or higher was set as an inclusion criterion for the study. Parents of all eligible children in each of the selected kindergarten classes were contacted, of whom 68% agreed to participate in the study. In addition, children who based on their parent reports had auditory or visual impairments or received treatment for sensory–motor problems were excluded. Fifty-six percent of the participants were first-borns. Ninety-five percent of participants' fathers and 98% of their mothers reported high school or higher levels of education. Eighty-eight percent of the parents were married and living together.

One year later, during the second semester of their first grade class, we collected school adjustment data for 71 children of the original sample (45 girls, 26 boys). Seventeen children (19.3%) dropped out from the study: five children remained an extra year in kindergarten, contact was lost with three of the families, and nine declined participation in the second phase of the study. Non-significant age or gender differences were found between children who continued participation and those who did not, $t(86) = 0.87$, $p = 0.39$ and $\chi^2 = 1.52$, $p = 0.22$, respectively. However, children who dropped out from the study had lower motor ability ($M = -2.12$, S.D. = 3.10) compared with children who continued participation ($M = 1.33$, S.D. = 4.73), $t(86) = 2.86$, $p < 0.005$.

Procedure

Three trained occupational therapists, who were blind to the study's hypotheses and goals, administered a battery of motor skills at each child's home during the second semester of the kindergarten year. The home visit included assessments of visual–motor integration, fine motor accuracy, visual–spatial perception, kinesthesia, and imitation of postures, all performed while the child was sitting next to a table. Children's muscle tone was assessed in the room space.

A year later, we assessed children's adjustment to first grade *via* a series of questionnaires completed by each child's class teacher and by the children themselves. Data were collected during the second semester of the school year to

ensure that children had the opportunity to adjust to their new school settings, and for teachers to better know their students. Children completed their questionnaires at home with the assistance of a graduate psychology student. Teachers completed their set of questionnaires at school, and were compensated $10 for their participation.

Measures

Assessment of Motor Function in Kindergarten

The selected motor tests were chosen to collectively provide a comprehensive representation of children's core motor abilities, including visual–motor integration, visual spatial perception, fine motor accuracy, muscle tone, imitation of postures, and kinesthesia. In addition, because Bar-Haim and Bart (2006) had demonstrated significant intercorrelations among the scores of the different motor function measures, and because principal component analysis indicated that all the motor function measures loaded on a single factor, we created an additional global index of general motor function by aggregating the *z*-scores of all tested motor measures.

The Developmental Test of Visual–Motor Integration (VMI): The VMI (Beery, 1989) consists of 24 geometric forms to be copied in sequence from a test booklet. The geometric forms become progressively more complex, and the score continues to accumulate either until all 24 forms have been successfully copied or until three consecutive forms are copied incorrectly. The VMI was designed for children ranging from two to 15 years of age and comes with age-specific norms.

The VMI contains two standardized supplemental subtests:

The Visual–Spatial Perception Test

This test assesses visual–spatial perception components without the requirement of motor action. On this test, the child is shown a target figure and is asked to select a matching figure from a set of 2–7 alternatives. The test consists of 24 figures that become progressively more complex.

The Fine Motor Accuracy Test

In this test, the child is required to draw a clear, dark line while staying inside a set of defined lines. There are 24 configurations that require progressively refined motor accuracy and control. A child's score on this subtest continues to accumulate either until all 24 items has been successfully completed or until three consecutive failures occur.

Beery (1989) reported mean scores of inter-rater, content sampling, and time sampling reliabilities of the VMI, the Visual–Spatial Perception Test, and the Fine Motor Accuracy Test, as 0.92, 0.91, and 0.89, respectively. In addition, concurrent validities with other tests of visual perception and integrative ability, as well as prospective prediction of school outcomes are reported at length in the VMI manual (see Beery, 1989).

Muscle Tone (Prone Extension and Supine Flexion): To obtain an index of participants' muscle tone and strength, children were asked to assume and maintain prone extension and supine flexion positions. The prone extension

assessment measures the child's ability to simultaneously lift the head, flexed arms, upper trunk, and extended legs from a prone-lying position. For the supine flexion assessment children were asked to assume a position of simultaneous flexion, against gravity, of the knees, hips, trunk, and neck from a supine-lying position. In the supine flexion assessment, the top of the head had to approximate the knees. The number of seconds a child maintained in each of these two positions was noted as the raw score. Normal children older than six years of age can generally maintain these postures for 20–30 s with moderate exertion (Ayres, 1972; Harris, 1981). The tests show high inter-rater reliability ($r = 0.90$, Bundy & Fisher, 1981), and no significant differences in performance between boys and girls (Harris, 1981).

In the present study, children's raw scores on the prone extension and the supine flexion tests were highly correlated, $r = 0.62$, $p < 0.0001$. Therefore, the scores of the two measures were summed to create an aggregate index referred to as muscle tone.

Imitation of Postures: Children's ability to perceive and replicate different body positions was determined by the Imitation of Postures subtest from the Sensory Integration and Praxis Tests (SIPT, Ayres, 1989). This test requires children to assume a series of 12 positions/postures demonstrated by the examiner. Two points are scored for postures that are imitated correctly within 3 s after the examiner assumed the posture. One point is noted if the child imitates the posture correctly within 4–10 s. No points are scored if the correct posture is assumed after 10 s, or if it does not meet the criteria for a score of 1 or 2 points. The raw score of the test is computed as the sum total number of points noted for the 12 test items. Raw scores are converted to standard age-related scores. Test–retest stability of the Imitation of Postures subtest has been reported to be 0.71. Additional information on reliability and validity of the test may be found in the SIPT manual (Ayres, 1989).

Kinesthesia: Kinesthesia was measured using the KIN sub-test from the SIPT (Ayres, 1989). In this subtest, the experimenter moves the child's hand from one predetermined point on a paper chart to another while the child's hands remain out of his or her visual field. The child is then asked to repeat the motion on the kinesthesia chart, again without seeing his or her hands. The KIN consists of 10 test items, five for each hand. Hands are tested in an alternated sequence. The KIN score is based on how accurately the child replicates the rehearsed motion, measured as the distance in millimetres of the child's finger from the predetermined target points. Raw scores are converted to standard age-related scores. Although the test–retest stability of the KIN subtest has been reported to be rather low, $r = 0.53$, support for its construct validity has been demonstrated in a number of studies with different age groups (Ayres, 1965, 1977; Ayres, Mailloux, & Wndler, 1987). Full information on reliability and validity of the KIN may be found in the SIPT manual (Ayres, 1989).

Assessment of Adjustment to Formal Schooling

Teacher Reports

   Child Behaviour Scale (CBS, Ladd & Profilet, 1996)
This teacher-rated questionnaire contains 59 items of which 35 are conceptually grouped into six subscales tapping the following target constructs: aggressive with

peers (7 items, $\alpha = 0.89$)[2], prosocial with peers (7 items, $\alpha = 0.83$), asocial with peers (6 items, $\alpha = 0.92$), anxious-fearful (4 items, $\alpha = 0.79$), excluded by peers (7 items, $\alpha = 0.93$), and hyperactive-distractible (4 items, $\alpha = 0.79$).

Teacher–Child Rating Scale (TCRS, Hightower et al., 1986)
This teacher-rated instrument consists of 43 items describing behaviours of children in school. The responses are grouped into six factors: acting out (6 items, $\alpha = 0.90$), shy-anxious (6 items, $\alpha = 0.84$), learning problems (6 items, $\alpha = 0.89$), frustration tolerance (11 items, $\alpha = 0.90$), assertive social skills (7 items, $\alpha = 0.83$), and task orientation (8 items, $\alpha = 0.93$).

Teacher Rating Scale of School Adjustment (TRSSA, Ladd, 1992)
The TRSSA consists of 52 teacher-rated items that tap into five constructs reflecting children's behaviour in school and class settings. Responses are grouped into five factors: cooperative participation (7 items, $\alpha = 0.91$), self-directedness (4 items, $\alpha = 0.90$), teacher's perception of children's school liking (5 items, $\alpha = 0.91$), teacher's perception of children's school avoidance, (5 items, $\alpha = 0.75$), and teacher's perception of children's interest/comfort with the teacher (5 items, $\alpha = 0.66$).

Data reduction of teacher's ratings
Standardized scores of all the teacher-rated sub-scales derived from the CBS, TCRS, and TRSSA were entered into a principal component analysis with varimax rotation. This factor analysis yielded four factors with eigenvalues greater than 1, which together explained 79.58% of the variance. Table 1 presents factor loading for the teacher-reported scales. The first factor, *disruptive behaviour*, consisted of the sum of z-scores of the TCRS—acting out, TCRS—frustration tolerance reversed, CBS—aggressive with peers, TRSSA—cooperative participation reversed, and TRSSA—school avoidance, accounting for 26.12% of the variance. The second factor, *scholastic adaptation*, is the sum of z-scores on the TCRS—task orientation, TCRS—learning problems reversed, and TRSSA—self-directedness, accounting for additional 24.52% of the variance. The third factor, *anxious-withdrawn*, includes CBS—asocial with peers, CBS—anxious-fearful, and TCRS—shy-anxious, accounting for additional 15.07% of the variance. Finally, the fourth factor, *pro-social behaviour*, consisted of the sum of z-scores of the CBS—prosocial with peers scale, and the TRSSA—comfort with teacher scale, accounting for additional 13.87% of the variance.

Children's Subjective Reports
The Loneliness and Social Dissatisfaction Questionnaire (LSDQ, Asher & Wheeler, 1985)
The LSDQ was used to assess children's feelings of loneliness in the school setting. This questionnaire consists of 16 target statements focused on children's feelings of loneliness (e.g. 'I feel lonely at school'). Interspersed with the items related to loneliness were eight additional 'filler' items that focused on children's hobbies or preferred activities (e.g. 'I like music'). The filler items were included to help children feel more open and relaxed about indicating their attitudes about various topics (see Cassidy & Asher, 1992). A loneliness score was computed as the average of all target loneliness statements, with higher scores reflecting

Table 1. Factor loading for the teacher-reported scales

Teacher-Reported Scales	Factor 1 Disruptive behaviour	Factor 2 Scholastic adaptation	Factor 3 Anxious withdrawn	Factor 4 Pro-social behaviour
Acting Out (TCRS)	0.86			
Aggressive with Peers (CBS)	0.83			
Frustration Tolerance (TCRS)	−0.71			
Cooperative Participation (TRSSA)	−0.67			
School Avoidance (TRSSA)	0.67			
Task Orientation (TCRS)		0.85		
Self-directedness (TRSSA)		0.83		
Learning Problems (TCRS)		−0.78		
Asocial with Peers (CBS)			0.77	
Shy-Anxious (TCRS)			0.74	
Anxious-Fearful (CBS)			0.74	
Prosocial with Peers (CBS)				0.79
Comfort with Teacher (TRSSA)				0.71

Scales that loaded with less then 0.40 coefficients on any of the factors, or that loaded on more than one factor were removed.

Table 2. Factor loading for the child-reported scales

Child-Reported Scales	Factor 1
School Liking (LSDQ)	0.86
School Avoidance (LSDQ)	−0.81
Loneliness (SLAQ)	0.80
Harter Pictorial Scale—Total	0.68

stronger feelings of loneliness. Cronbach's α for this scale in the present sample was 0.83.

The School Liking and Avoidance Questionnaire (SLAQ, Ladd, 2001; Ladd, Buhs, & Seid, 2000)
This questionnaire contains 14 items divided into two subscales: school liking (9 items, $\alpha = 0.92$), and children's expressed desire to avoid school or school avoidance (5 items, $\alpha = 0.86$)

Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (PSPCSA, Harter & Pike, 1984)
The *PSPCSA* was designed to assess 4–8 year-olds' self-esteem, and contains 24 items from four domains (cognitive competence, physical competence, peer acceptance, and maternal acceptance). Each item includes pictures of two children in different circumstances. The experimenter described one child in the pictures as very successful and the other as a child who struggles. Children were asked to choose the picture with which they identify most closely, and then select whether they highly or moderately identify with the child in the selected picture. A total self-esteem score was computed as the sum of all items, with high scores representing high self-esteem. Internal consistency of the total self-esteem scale in the present study was $\alpha = 0.84$.

Data reduction of children's ratings

Standardized scores of all the child-rated measures were entered into a principal component analysis with varimax rotation and loaded on a single factor, which explained 62.75% of the variance (Table 2). The LSDQ and School Avoidance loaded positively, and the PSPCSA and School Liking loaded negatively on this factor. An aggregate measure, *child subjective adaptation*, was computed with high scores reflecting good adaptation, and was used in all subsequent analyses.

RESULTS

To test the associations between motor abilities in kindergarten and adjustment to first grade we first computed simple Pearson correlations between these two sets of variables. We then used hierarchical regression models to further assess the relative contribution of the different motor functions to the prediction of each of the school adaptation indexes (i.e. scholastic adaptation, disruptive behaviour, anxious-withdrawn, pro-social behaviour, and child subjective adaptation).

Correlations between Motor Abilities in Kindergarten and Adjustment to First Grade

Table 3 presents Pearson correlations between the assessed motor abilities (VMI, visual–spatial perception, fine motor accuracy, muscle tone, imitation of postures, kinesthesia, and the general motor function aggregate) and children's adjustment to school as reported by teachers and children (scholastic adaptation, disruptive behaviour, anxious-withdrawn, pro-social behaviour, and child subjective adaptation).[3]

Better performance on each of the tested motor functions in kindergarten was significantly associated with better scholastic adaptation in first grade. Poor visual–motor integration, poor visual–spatial perception, low muscle tone, and poor kinesthesia in kindergarten were associated with significantly higher incidence of disruptive behaviour in first grade as reported by the class teachers. Low muscle tone and poor kinesthesia in kindergarten were associated with more anxious-withdrawn behaviour in first grade, and better visual–spatial

Table 3. Two-tailed Pearson correlations between motor abilities in kindergarten and measures of adjustment to first grade

	Scholastic adaptation	Disruptive behaviour	Anxious-withdrawn	Pro-social behaviour	Child subjective adaptation
VMI	0.40***	−0.29*	−0.10	0.18	0.03
Visual–spatial perception	0.47***	−0.33**	−0.18	0.24*	0.03
Fine motor accuracy	0.23***	−0.22+	−0.11	0.20	0.17
Muscle tone	0.29*	−0.26*	−0.27*	0.28*	0.22+
Imitation of postures	0.25*	−0.23+	−0.03	0.04	0.22+
Kinesthesia	0.41***	−0.35**	−0.27*	0.21+	0.13
General motor function	0.58***	−0.42***	−0.26*	0.30*	0.26*

$+p < 0.10$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

perception and muscle tone were significantly associated with more pro-social behaviour as reported by teachers. No single motor function was significantly associated with children's subjective report of adaptation to first grade. Finally, the aggregate measure representing general motor function in kindergarten was significantly associated with all the teacher-reported scales as well as with children's subjective reports of school adaptation.

Predicting Adjustment to First Grade from Motor Function in Kindergarten

Two sets of hierarchical regressions were computed in predicting each of the indexes of adaptation to first grade (scholastic adaptation, disruptive behaviour, anxious-withdrawn, pro-social behaviour, and child subjective adaptation). For each outcome measure, one regression assessed the relative contribution of each singular motor function to school adjustment; the other regression assessed prediction from the aggregate measure of general motor function as a sole predictor of school adjustment.

Gender was entered at the first step in both of the aforementioned regression models. In the second step of the first regression model, the six singular motor measures (VMI, visual–spatial perception, fine motor accuracy, muscle tone, imitation of postures, and kinesthesia) were entered in a stepwise mode. In the second regression model, the aggregate variable indexing general motor function was entered in the second step.

Scholastic Adaptation

Table 4 summarizes the results of the computed regression analyses. Gender did not account in a significant manner to the variance in scholastic adaptation to

Table 4. Regressing singular motor abilities and a general motor function in kindergarten on teacher-reported scholastic adaptation to first grade

	B (S.E.)	β	R^2
Singular motor measures			
Step 1			0.02
Gender	0.87 (0.75)	0.14	
Step 2			
Gender	0.02 (0.68)	0.14	
Visual–motor integration	—	0.20	
Visual–spatial perception	0.94 (0.32)	0.35[**]	
Fine motor accuracy	0.81 (0.42)	0.29[*]	
Muscle tone	—	0.18	
Imitation of postures	—	0.09	
Kinesthesia	—	0.18	
Total R^2			0.29
Motor aggregate			
Step 1			0.02
Gender	0.87 (0.75)	0.14	
Step 2			
Gender	0.23 (0.64)	0.04	
General motor function	0.37 (0.07)	0.57[***]	
Total R^2			0.33

—variable excluded, [*]$p<0.05$, [**]$p<0.005$, [***]$p<0.0001$.

Table 5. Regressing singular motor abilities and a general motor function in kindergarten on teacher-reported disruptive behaviour in first grade

	B (S.E.)	β	R^2
Singular motor measures			
Step 1			0.02
Gender	−1.37 (1.09)	−0.16	
Step 2			
Gender	−0.87 (1.06)	−0.10	
Visual–motor integration	—	−0.20	
Visual–spatial perception	−1.23 (0.48)	−0.31[*]	
Fine motor accuracy	—	−0.09	
Muscle tone	—	−0.22	
Imitation of postures	—	−0.12	
Kinesthesia	—	−0.21	
Total R^2			0.12
Motor aggregate			
Step 1			0.02
Gender	−1.37 (1.09)	−0.16	
Step 2			
Gender	−0.72 (1.02)	−0.08	
General Motor Function	−0.38 (0.11)	−0.40[**]	
Total R^2			0.18

—variable excluded, [*]$p < 0.05$, [**]$p < 0.001$.

first grade, $F(1, 64) = 1.33$, $p > 0.25$. The stepwise regression revealed that visual–spatial perception and fine motor accuracy in kindergarten significantly and uniquely contributed to the prediction, together explaining 29% of the variance in scholastic adaptation to first grade, $F(3, 64) = 8.37$, $p < 0.0001$. Entering the general motor function variable at the second step of the regression as a sole predictor showed that it accounted for 33% of the variance in scholastic adaptation, $F(2, 64) = 15.46$, $p < 0.0001$.

Disruptive Behaviour

Table 5 summarizes the results of the computed regression analyses. Gender did not account in a significant manner to the variance in disruptive behaviour in first grade, $F(1, 64) = 1.58$, $p > 0.20$. The first stepwise regression revealed that low visual–spatial perception in kindergarten was the only variable contributing to the prediction of disruptive behaviour in first grade, $F(2, 64) = 4.23$, $p < 0.05$, explaining 12% of the variance. Entering the general motor function variable at the second step of the regression as a sole predictor showed that it accounts for 18% of the variance in disruptive behaviour, $F(2, 64) = 6.82$, $p < 0.005$.

Anxious-withdrawn Behaviour

Table 6 summarizes the results of the computed regression analyses. Again, gender did not account in a significant manner to the variance in anxious-withdrawn behaviour in first grade, $F(1, 64) = 0.51$, $p > 0.45$. The stepwise regression analysis revealed that kinesthesia was the only variable contributing to prediction, explaining 9% of the variance in anxious-withdrawn

Table 6.   Regressing singular motor abilities and a general motor function in kindergarten on teacher-reported anxious-withdrawn behaviour in first grade

	B (S.E.)	β	R^2
Singular motor measures			
Step 1			0.008
Gender	0.44 (0.62)	0.09	
Step 2			
Gender	0.67 (0.61)	0.14	
Visual–motor integration	—	−0.03	
Visual–spatial perception	—	−0.10	
Fine motor accuracy	—	−0.06	
Muscle tone	—	−0.18	
Imitation of postures	—	0.21	
Kinesthesia	−0.44 (0.19)	−0.29[*]	
Total R^2			0.09
Motor aggregate			
Step 1			0.008
Gender	0.44 (0.62)	0.09	
Step 2			
Gender	0.71 (0.61)	0.14	
General motor function	−0.16 (0.07)	−0.29[*]	
Total R^2			0.09

—variable excluded, [*]$p < 0.05$.

Table 7.   Regressing singular motor abilities and a general motor function in kindergarten on teacher-reported pro-social behaviour in first grade

	B (S.E.)	β	R^2
Singular motor measures			
Step 1			0.05
Gender	0.88 (0.47)	0.23	
Step 2			
Gender	1.04 (0.46)	0.28[*]	
Visual–motor integration	—	0.10	
Visual–spatial perception	—	0.15	
Fine motor accuracy	—	0.07	
Muscle tone	0.53 (0.20)	0.31[**]	
Imitation of postures	—	−0.09	
Kinesthesia	—	0.10	
Total R^2			0.15
Motor aggregate			
Step 1			
Gender	0.88 (0.47)	0.23	
Step 2			
Gender	0.69 (0.47)	0.18	
General motor function	0.11 (0.05)	0.26[*]	
Total R^2			0.12

—variable excluded, [*]$p < 0.05$, [**]$p < 0.01$.

behaviour in first grade, $F(2, 64) = 3.02$, $p = 0.056$. Entering the general motor function variable at the second step of the regression as a sole predictor showed that it also accounted for 9% of the variance in anxious-withdrawn

behaviour, $F(2, 64) = 3.01$, $p = 0.056$, thus not improving prediction over that of kinesthesia alone.

Pro-social Behaviour

Table 7 summarizes the results of the computed regression analyses. As a single predictor at step 1 of the regression analyses, gender accounted for 5% of the variance in pro-social behaviour in first grade, $F(1, 64) = 3.47$, $p = 0.067$. Step 2 of the stepwise regression analysis revealed that gender and muscle tone in kindergarten significantly and uniquely contributed to prediction, together explaining 15% of the variance in pro-social behaviour in first grade, $F(2, 64) = 5.28$, $p < 0.01$. Entering the general motor function variable at the second step of the regression as a sole predictor showed that it accounted for only 12% of the variance in pro-social behaviour, $F(2, 64) = 4.21$, $p < 0.05$.

To follow-up on the significant gender effect, separate regression analyses for boys and for girls were computed. These analyses revealed that none of the motor variables predicted pro-social behaviour in first grade for boys. In contrast, muscle tone, visual–spatial perception, and imitation of postures in kindergarten significantly and uniquely contributed to prediction, together explaining 32% of the variance in pro-social behaviour in girls, $F(3, 42) = 6.20$, $p < 0.005$.

Children's Subjective Feelings of Adaptation to First Grade

Gender did not account in a significant manner to the variance in children's self-reported adjustment to first grade, $F(1, 69) = 1.19$, $p > 0.85$, and neither did any of the motor function variables entered at step 2 of the stepwise regression analysis. Entering the general motor function variable at the second step of the regression as a sole predictor showed that it accounted for 7% of the variance in children's self-reported adjustment to school, but this regression model effect was only at a trend level of significance, $F(2, 69) = 2.40$, $p = 0.098$.

DISCUSSION

Three main findings emanate from the present study: first, although scholastic adaptation may be predicted from a standard test of visual–motor integration, other tests of motor function such as kinesthesia, muscle tone, and imitation of postures are also significantly associated with scholastic adaptation. Second, our data show that in addition to the predictive value of motor functions to scholastic adaptation in first grade, motor functions also predict a significant portion of the variance of children's social and emotional adjustment to school. Finally, our analyses indicate that a better prediction of scholastic adaptation and disruptive behaviour in school may be achieved by using an aggregate measure of various motor abilities than by using assessments of singular motor functions.

The focus of attempts at predicting academic adjustment from motor ability has been on the aspect of visual–motor integration (e.g. Carlton & Winsler, 1999; Kurdek & Sinclair, 2000; Schaaf *et al.*, 1987; Schoemaker & Kalverboer, 1994; Sortor & Kulp, 2003; Taylor, 1999). Indeed, our findings also indicate a central predictive value for elements of visual–motor integration in scholastic adaptation. Interestingly, however, in our sample the combination of the separate measures of visual–spatial perception and fine motor accuracy from the Developmental Test of Visual–Motor Integration predicted 29% of the variance

in scholastic adaptation, whereas the predictive value of the VMI subtest within this model was redundant. In addition, a somewhat better prediction of 33% of the variance in scholastic adaptation was achieved by using an aggregate measure including all the assessed motor functions. The cost effectiveness related to these additional 4% in predictive value should be determined relative to the goals of prediction.

In addition to the prediction of academic adjustment from motor measures, our findings clearly demonstrate that motor abilities assessed in kindergarten significantly contribute to the prediction of important elements of social and emotional adjustment to school. Teacher reports of high anxious-withdrawn behaviour and low prosocial behaviour were significantly predicted from children's low performance on the kinesthesia test (9% of the variance) and muscle tone test (15% of the variance) in kindergarten. In addition, children's positive self-reported emotional adjustment to school was associated with better general motor function in kindergarten. These findings are in accord with Bar-Haim and Bart (2006), who found significant associations between motor abilities and prosocial as well as anxious-reticent behaviour in normally developing kindergarten children. These findings are also in accord with clinical observations indicating that children with motor difficulties tend to show more social problems, loneliness, low self-esteem, and high levels of anxiety (Dewey *et al.*, 2002; Skinner & Piek, 2001; Smyth & Anderson, 2000, 2001). Apparently, repeated failures in academic and social performance in school, partly due to poor motor planning or poor muscle tone, might lead a child to withdraw from such activities, lose self-confidence, and become more anxious and withdrawn at school.

In addition, our study shows that 12% of the variance in children's disruptive behaviour in first grade may be predicted from their performance on the visual–spatial perception subtest of the VMI in kindergarten. An additional 6% of the variance in disruptive behaviour in first grade may be explained by using the more comprehensive index of general motor function. It is reasonable to assume that poor visual–spatial ability would be related to increased frustration, difficulties in sustaining attention on academic assignments, and possibly with poor overall achievement. Such a profile may support a tendency for disruptive behaviour in the school context.

While the general association between motor ability and social and emotional adjustment to school is clearly supported, it is difficult to explicate the specific nature of some of these associations (e.g. anxious-withdrawn behaviour and kinesthesia). Replication and extension of the present findings are necessary before meaningful interpretation may be offered. However, based on the predictive value of motor abilities to social and emotional adjustment to school it seems reasonable to consider the inclusion of motor measures along with typically used measures of social and emotional maturation (e.g. the Social Skills Rating System, Gresham & Elliott, 1990) in future attempts at predicting social and emotional aspects of adjustment to school.

Although the present findings generally suggest a non-significant role for gender in the association between motor ability and school adjustment, surprisingly, low muscle tone, visual–spatial perception, and imitation of postures in kindergarten significantly contributed to the prediction of lower levels of pro-social behaviour in school for girls but not for boys. This finding runs somewhat counter to previous research findings describing boys' motor play behaviour at school as more vigorous (Blatchford *et al.*, 2003; Fabes, Martin, & Hanish, 2003; Harper & Sanders, 1975), which would imply that in order to 'fit

in' boys may be more dependent than girls would be on good motor abilities. Further research replicating our findings regarding the special importance of motor skills for girls' pro-social behaviour is necessary before further conclusions may be drawn.

It is important to note that there was a selective dropout from the second phase of the study of children with low motor abilities. It may be that children with low motor ability were frustrated by the motor assessment during the first stage of the study and did not want to participate again. Additionally, in accord with our prediction, children with low motor ability experienced greater difficulties in school adjustment, and thus, the poorly coordinated children who dropped out of the study have possibly avoided the extra challenge of participation in our research. Despite this selective dropout, however, meaningful associations between motor performance in kindergarten and adjustment to formal schooling were found. These findings most probably reflect an underestimation of the predictive value of motor function to school adjustment. Thus, we believe that children's motor abilities in kindergarten may be an even more solid predictor of children's functioning in the transition to school.

Although the findings of the present study show that motor ability in kindergarten predicts scholastic and social–emotional adjustment, our findings do not allow a clear-cut inference of causality. It may be that other factors serve as a causal source for both motor difficulties and suboptimal academic and social–emotional adjustment to school. For instance, Hall, McLeod, Counsell, Thomson, and Mutch (1995) reported that children with very low birth weight had more motor and learning difficulties at eight years of age compared to control children with normal birth weight. In the same vein, Miyahara *et al.* (2003) found that the presence and extent of neonatal brain lesions was the most powerful predictor of children's perceptual motor function at six years of age. Such brain anomalies and consequential averted maturation processes may affect children's motor development as well as their cognitive and emotional functioning (e.g. executive function, attention, emotion regulation). Further experimentally oriented research is needed to clarify the causal mechanisms involved in the aforementioned associations between motor function and school adjustment.

In conclusion, the findings of the present study suggest that good motor abilities are associated with better scholastic adaptation and more prosocial behaviour in the transition to formal schooling. Thus, good motor ability appears to serve as a buffer to the normative challenges presented to children in the transition to school. In contrast, poor motor ability emerges as a vulnerability factor in the transition to formal schooling, which may lead children to both externalizing and internalizing behaviour difficulties in school. Early assessment of children's motor function, before school entry, could allow for motor-oriented intervention that may facilitate the transition to school for children with suboptimal motor ability. Such intervention could range from occupational therapy in cases of more severe motor dysfunctions, to common extracurricular motor activities such as swimming, gymnastics, or martial arts classes.

Notes

1. In Israel, the critical transition to formal schooling occurs between kindergarten and first grade. Therefore, we focused our study on this transition period.
2. α values for each of the scales are reported for the present sample.

3. Separate correlation analyses between motor functions and adjustment to first grade by gender revealed similar patterns for boys and girls with the following exceptions. A significantly larger negative correlation between visual–spatial perception in kindergarten and disruptive behaviour in school for girls, $r=-0.56$ than boys, $r=-0.06$, $p<0.05$. A significantly larger correlation between imitation of postures in kindergarten and anxious withdrawn behaviour in school for boys, $r=-0.58$ than girls, $r=0.08$, $p<0.05$. And, a significantly larger correlation between visual–motor integration in kindergarten and children's subjective adaptation in school for boys, $r = 0.48$ than girls, $r = -0.01$, $p<0.05$.

REFERENCES

Alexander, K. L., & Entwisle, D. R. (1988). Achievement in the first two years of school: Patterns and processes. *Monographs of the Society for Research in Child Development, 53* (2, Serial No. 218).

Alexander, K. L., Entwisle, D. R., & Olson, L. S. (2001). Schools, achievement, and inequality: A seasonal perspective. *Educational Evaluation and Policy Analysis, 23*, 171–191.

Asher, S. R., & Wheeler, V. A. (1985). Children's loneliness: A comparison of rejected and neglected peer status. *Journal of Consulting and Clinical Psychology, 53*, 500–505.

Ayres, A. J. (1965). Patterns of perceptual–motor dysfunction in children: A factor analytic study. *Perceptual and Motor Skills, 20*, 335–368.

Ayres, A. J. (1972). *Sensory integration in learning disorders*. Los Angeles: Western Psychological Services.

Ayres, A. J. (1977). Cluster analysis of measures of sensory integration. *American Journal of Occupational Therapy, 31*, 362–366.

Ayres, A. J. (1980). *Sensory integration and the child*. Los Angeles: Western Psychological Services.

Ayres, A. J. (1989). *Sensory integration and Praxis tests*. Los Angeles, CA: Western Psychological Services.

Ayres, A. J., Mailloux, Z., & Wndler, C. L. (1987). Developmental dyspraxis: Is it a unitary function? *Occupational Therapy Journal of Research, 7*, 93–110.

Bar-Haim, Y., & Bart, O. (2006). Motor function and social participation in kindergarten children. *Social Development, 15*, 296–310.

Beery, K. E. (1989). *The developmental test of visual–motor integration* (3rd ed.). Cleveland: Modern Curriculum Press.

Belsky, J., & MacKinnon, C. (1994). Transition to school: Developmental trajectories and school experiences. *Early Education and Development, 5*, 106–119.

Birch, S. H., & Ladd, G. W. (1997). The teacher–child relationship and children's early school adjustment. *Journal of School Psychology*, 61–79.

Blatchford, P., Baines, E., & Pellegrini, A. D. (2003). The social context of school playground games: Sex and ethnic differences, and changes over time after entry to junior school. *British Journal of Developmental Psychology, 21*, 481–505.

Buhs, E. S., & Ladd, G. W. (2001). Peer rejection as an antecedent of young children's school adjustment: An examination of mediating processes. *Developmental Psychology, 37*, 550–560.

Bundy, A. C., & Fisher, A. G. (1981). The relationship of prone extension to other vestibular functions. *American Journal of Occupational Therapy, 35*, 782–787.

Carlton, M. P., & Winsler, A. (1999). School readiness: The need for a paradigm shift. *School Psychology Review, 28*, 338–352.

Case-Smith, J. (1998). Fine motor and functional performance outcomes in preschool children. *American Journal of Occupational Therapy, 50*, 52–61.

Cassidy, J., & Asher, S. R. (1992). Loneliness and peer relations in young children. *Child Development, 63*, 350–365.

Chen, X. Y., Rubin, K. H., & Li, D. (1997). Relation between academic achievement and social adjustment: Evidence from Chinese children. *Developmental Psychology, 33*, 518–525.

Dewey, D., Kaplan, B. J., Crawford, S. G., & Wilson, B. N. (2002). Developmental coordination disorder: Associated problems in attention, learning, and psychosocial adjustment. *Human Movement Science, 21,* 905–918.

Fabes, R. A., Martin, C. L., & Hanish, L. D. (2003). Young children's play qualities in same-, other- and mixed-sex peer groups. *Child Development, 74,* 921–932.

Goodman, S. H., Brumley, H., Schwartz, K. R., & Purcell, D. W. (1993). Gender and age in the relation between stress and children's school adjustment. *Journal of Early Adolescence, 13,* 329–345.

Gresham, F., & Elliott, S. (1990). *Social skills rating system.* Circle Pines, MN: American Guidance Service.

Haines, A. H., Fowler, S. A., Schwartz, I. S., Kottwitz, E., & Rosenhoetter, S. (1989). A comparison of preschool and kindergarten teacher expectations for school readiness. *Early Childhood Research Quarterly, 4,* 75–80.

Hall, A., McLeod, A., Counsell, C., Thomson, L., & Mutch, L. (1995). School attainment, cognitive ability and motor function in a total Scottish very low birthweight population at eight years: A controlled study. *Developmental Medicine and Child Neurology, 37,* 1037–1050.

Harper, L. V., & Sanders, K. M. (1975). Preschool children's use of space: Sex differences in outdoor play. *Developmental Psychology, 11,* 119.

Harris, N. P. (1981). Duration and quality of the prone extension position in four-, six-, and eight-year-old normal children. *American Journal of Occupational Therapy, 35,* 26–30.

Harter, S., & Pike, R. (1984). The pictorial scale of perceived competence and social acceptance for young children. *Child Development, 55,* 1969–1982.

Henderson, S. E., & Hall, D. (1982). Concomitants of clumsiness in young school children. *Developmental Medicine and Child Neurology, 24,* 448–460.

Hightower, A. D., Work, W. C., Cowen, E. L., Lotyczewski, B. S., Spinell, A. P., Guare, J. C., *et al.* (1986). The Teacher–child Rating Scale: A brief objective measure of elementary children's school problem behaviours and competencies. *School Psychology Review, 15,* 393–409.

Howes, C. (2000). Social-emotional classroom climate in child care, child–teacher relationships and children's second grade peer relations. *Social Development, 9,* 191–204.

Kurdek, L. A., & Sinclair, R. J. (2000). Psychological, family, and peer predictors of academic outcomes in first- through fifth-grade children. *Journal of Educational Psychology, 92,* 449–457.

Ladd, G. W. (1990). Having friends, keeping friends, making friends and being liked by peers in the classroom: Predictors of children's early school adjustment. *Child Development, 61,* 1081–1100.

Ladd, G. W. (1992). *The Teacher Rating Scale of School Adjustment—TRSSA.* Unpublished Manual, University of Illinois at Urbana-Champaign.

Ladd, G. W. (2001). *School Liking and Avoidance Questionnaire—SLAQ.* Unpublished Manual, University of Illinois at Urbana-Champaign.

Ladd, G. W., Birch, S. H., & Buhs, E. C. (1999). Children's social and scholastic lives in kindergarten: Related spheres of influence? *Child Development, 70,* 1373–1400.

Ladd, G. W., Buhs, E. S., & Seid, M. (2000). Children's initial sentiments about kindergarten: Is school liking an antecedent of early classroom participation and achievement? *Merrill-Palmer Quarterly, 46,* 255–279.

Ladd, G. W., Kochenderfer, B. J., & Coleman, C. C. (1996). Friendship quality as a predictor of young children's early school adjustment. *Child Development, 67,* 1103–1118.

Ladd, G. W., & Price, J. M. (1987). Predicting children's social and school adjustment following the transition from preschool to kindergarten. *Child Development, 58,* 1168–1189.

Ladd, G. W., & Profilet, S. M. (1996). The Child Behaviour Scale: A teacher-report measure of young children's aggressive, withdrawn, and prosocial behaviors. *Developmental Psychology, 32,* 1008–1024.

Lane, S. J. (2002). Sensory modulation. In A. C. Bundy, S. J. Lane, & E. A. Murray (Eds.), *Sensory integration theory and practice* (pp. 101–120). Philadelphia, PA: F. A. Davis Company.

Levine, M. D. (1987). Motor implementation. In M. D. Levine (Ed.), *Developmental variation and learning disorders* (pp. 208–239). Cambridge: Educators Publishing Service.

Mantzicopoulos, P., Morrison, D. C., Hinshaw, S. P., & Carte, E. T. (1989). Nonpromotion in kindergarten: The role of cognitive, perceptual, visual–motor, behavioral, achievement,

socioeconomic, and demographic characteristics. *American Educational Research Journal, 26*, 107–121.

McDermott, P. A. (1995). Sex, race, class, and other demographics as explanations for children's ability and adjustment: A national appraisal. *Journal of School Psychology, 33*, 75–91.

McHale, K., & Cermak, S. (1992). Fine motor activities in elementary school: Preliminary findings and provisional implications for children with fine motor problems. *American Journal of Occupational Therapy, 46*, 898–903.

McWayne, C. M., Fantuzzo, J. W., & McDermott, P. A. (2004). Preschool competency in context: An investigation of the unique contribution of child competencies to early academic success. *Developmental Psychology, 40*, 633–645.

Miyahara, M., Jongmans, M. J., Mercuri, E., de Vries, L. S., Henderson, L., & Henderson, S. E. (2003). Multiple birth versus neonatal brain lesions in children born prematurely as predictors of perceptuo-motor impairment at age 6. *Developmental Neuropsychology, 24*, 435–459.

Nelson, R. F. (2004). The transition to kindergarten. *Early Childhood Education Journal, 32*, 187–190.

Parham, L. D., & Fazio, L. S. (1997). *Play in occupational therapy for children*. London: Mosby.

Pellegrini, A.D., Blatchford, P., Kato, K., & Baines, E. (2004). A short-term longitudinal study of children's playground games in primary school: Implications for adjustment to school and social adjustment in the USA and the UK. *Social Development, 13*, 107–123.

Pianta, R. C., Cox, M. J., Taylor, L., & Early, D. (1999). Kindergarten teachers' practices related to the transition to school: Results of a national survey. *Elementary School Journal, 100*, 71–86.

Pianta, R. C., & Stuhlman, M. W. (2004). Teacher–child relationships and children's success in the first years of school. *School Psychology Review, 33*, 444–458.

Piek, J. P., Dworcan, M., Barrett, N., & Coleman, R. (2000). Determinants of self-worth in children with and without developmental coordination disorder. *The International Journal of Disability, Development, and Education, 47*, 259–271.

Rimm-Kaufman, S. E., & Pianta, R. C. (2000). An ecological perspective on the transition to kindergarten: A theoretical framework to guide empirical research. *Journal of Applied Developmental Psychology, 21*, 491–511.

Risi, S., Gerhardstein, R., & Kinster, J. (2003). Children's classroom peer relationships and subsequent educational outcomes. *Journal of Clinical Child and Adolescent Psychology, 32*, 351–361.

Schaaf, R., Merril, S., & Kinsella, N. (1987). Sensory integration and play behavior: A case study of the effectiveness of occupational therapy using sensory integrative techniques. *Occupational Therapy in Health Care, 4*, 61–75.

Schoemaker, M. M., & Kalverboer, A. F. (1994). Social and affective problems of children who are clumsy: How early do they begin? *Adaptive Physical Activity Quarterly, 11*, 130–140.

Simner, M. L. (1989). Predictive validity of an abbreviated version of the Printing Performance School Readiness Test. *Journal of School Psychology, 27*, 189–195.

Simpson, M. L., Cristo, M. G., & Gibbons, R. D. (1993). New directions in education perceived by 590 Virginia teachers. *Perceptual and Motor Skills, 77*, 43–53.

Skinner, R. A., & Piek, J. P. (2001). Psychosocial implications of poor motor coordination in children and adolescents. *Human Movement Science, 20*, 73–94.

Smits-Engelsman, B. C. M., Niemeijer, A. S., & Van-Galen, G. P. (2001). Fine motor deficiencies in children diagnosed as DCD based on poor grapho-motor ability. *Human Movement Science, 20*, 161–182.

Smyth, M. M., & Anderson, H. I. (2000). Coping with clumsiness in school playground: Social and physical play in children with coordination impairments. *British Journal of Developmental Psychology, 18*, 389–413.

Smyth, M. M., & Anderson, H. I. (2001). Football participation in the primary school playground: The role of coordination impairments. *British Journal of Developmental Psychology, 19*, 369–379.

Sortor, J. M., & Kulp, M. T. (2003). Are the results of the Beery-Buktenica Developmental Test of Visual–Motor Integration and its subtests related to achievement test scores? *Optometry & Vision Science, 80*, 758–763.

Stipek, D. J., & Byler, P. (1997). Early childhood education teachers: Do they practice what they preach? *Early Childhood Research Quarterly, 12*, 305–325.

Taylor, K. M. (1999). Relationship between visual motor integration skill and academic performance in kindergarten through third grade. *Optometry & Vision Science, 76*, 159–163.

Tseng, M. H., & Chow, S. M. (2000). Perceptual–motor function of school-age children with slow handwriting speed. *American Journal of Occupational Therapy, 54*, 83–88.

Wilson, P.H., Maruff, P., Ives, S., & Currie, J. (2001). Abnormalities of motor and praxis imagery in children with DCD. *Human Movement Science, 20*, 135–159.