

Paper II

Motor coordination difficulties in 6-year-old children with severe behavioural and emotional problems

Synnøve Iversen, MSc, PT, Research fellow, Section of Physiotherapy Science, Department of Public Health and Primary Health Care, University of Bergen, Norway;

Ann-Mari Knivsberg, PhD, Professor, National Centre for Reading Education and Research, University of Stavanger, Norway;

Bjørn Ellertsen, PhD, Professor, Clinical neuropsychologist, National Centre for Reading Education and Research, University of Stavanger, Norway;

Magne Nødland, MA, Speech therapist, Madlavoll School, Stavanger, Norway;

Tommy Både Larsen, PT, Municipal Physio-and Occupational Therapy Services, Bamble, Norway.

Abstract

Incidence, severity and types of motor difficulties in children with severe behavioral and emotional problems were evaluated. A group of 6-year-olds (n=29) with such problems and controls (n=29) were compared on the Movement Assessment Battery for Children. The groups were compared on total scores as well as manual dexterity, ball-skills and balance. Individual M-ABC profiles were compared with Teacher's Report Form profiles. It was found that 62.1 % in the high-risk group and 20.7 % in the control group showed motor coordination difficulties. In the high-risk group 55.2 % fulfilled the criteria of the DSM-IV for developmental coordination disorder, compared to 3.4 % controls. The high-risk group showed significant difficulties within all sub-areas of the M-ABC. There was a significant relationship between attention problems and manual dexterity difficulties. The combination of problems identified makes these children vulnerable with regard to school inclusion and in need of proper assessment and intervention.

Keywords

Developmental coordination disorder, behavioral and emotional problems, Movement Assessment Battery for Children, attention problems, manual dexterity difficulties

Introduction

How to conceptualize various developmental disorders has been, and continues to be, a debated issue. One feature of these children's problems frequently stand out (e.g. attention deficits, motor problems, learning difficulties, behaviour problems, social problems), but research from various developmental fields has demonstrated that children often present with various combinations of such difficulties (Dewey et al., 2002; Henderson and Barnett, 1998; Kaplan et al., 1998; Nicolson and Fawcett, 1999; Ramus et al., 2003; Richardson & Ross, 2000). As a result of this frequent comorbidity, incorporating and superior terms such as "Neurodevelopmental Dysfunction" (NDD) (Bax, 1998) and "Atypical Brain Development" (ABD) (Dewey et al., 2002; Kaplan et al., 1998) have been suggested. However, although comorbidity is a widely acknowledged phenomenon, it is still quite often neglected within research as well as in clinical practice (Dewey et al., 2002; Visser, 2003). In this article we focus on the co-occurrence of motor coordination difficulties in 6-year old children with severe behavioural and emotional problems.

Children with severe behavioural and emotional difficulties may have a variety of traits that point to different developmental disorders or syndromes (Campbell, 1995). Diagnostic considerations are, however, difficult in young children. This is illustrated by the various terms used to describe the group; "children at risk", "high risk children", "children with problem behaviour" (Campbell, 1990), "hard to manage preschool children" (Pierce et al., 1999), and children with "early problem behaviour" (Keenan et al., 1998).

The problem behaviour may be internalized or externalized (Keenan et al., 1998), or both (Achenbach, 1991). Withdrawal, anxiety, depression and somatic complaints characterize internalizing behaviour (Achenbach, 1991), and also passivity, fear, and lack of curiosity (Campbell, 1995). Externalizing behaviour is characterized by delinquent and aggressive behaviour (Achenbach, 1991). Attention problems may co-exist with internalizing (Achenbach, 1991) as well as externalizing and hyperactive behaviour (e.g. Campbell, 1995; Keenan et al. 1998).

Problem behaviour is reported in 7 to 11% of young children (Hellgren et al., 1994; Newth & Corbett, 1993), and approximately half of them may be severely affected (Ogden, 2002). Cognitive and linguistic delays are common in these children and so are attention problems (Cantwell et al., 1979; Cohen et al., 1989; Kadesjö & Gillberg, 1998; Landgren et al., 2000; McGee et al., 1991; White et al., 1990). Severe problems often indicate a risk for future behavioural and academic problems for the individual child (Goodman & Scott, 1997; Ogden 2002), as well as difficulties in establishing and maintaining peer relationships (Ogden, 2002).

Children with motor coordination difficulties have been described in a variety of terms (Missiuna & Polatajko, 1995; Henderson & Barnett, 1998) until researchers in 1994 agreed to use the term "Developmental Coordination Disorder" (DCD) from the DSM-IV (American Psychiatric Association (APA), 1994) (Polatajko et al., 1995). According to the DSM-IV criteria, the children must present with motor function significantly below chronological age (criterion A). The motor impairment must interfere

significantly with activities of daily living (criterion B), and must not be related to a medical condition (criterion C). Criterion D states that the diagnosis developmental coordination disorder may be used in cases of mental retardation when the motor problems are in excess of those usually observed (Geuze et al., 2001).

According to international estimates, the prevalence of DCD is at least 5-6 % (APA, 1994). Problems at all levels of function, as described in the World Health Organization (WHO)'s International classification of functioning, disability and health (ICF) (WHO, 2001), have been reported for children with DCD. At the level of body function and structure there are reports on general slowness of movement (Henderson et al., 1992; Rösblad & von Hofsten, 1994), information processing difficulties (see Wilson & McKenzie, 1998, for an overview), and decreased power and strength (O'Beirne et al., 1994; Raynor, 2001). At the level of activities of daily life, running, jumping, climbing, riding a bike, swimming and ball games are difficult for the children, and so is dressing, writing and using various tools (Cermak et al., 2002; Sugden & Wright, 1998). Anxiety, lack of motivation, withdrawal from school activities and play has been reported for children with DCD at participation level (Hay & Missiuna, 1998; Losse et al., 1991; Schoemaker & Kalverboer, 1994).

In a developmental perspective, motor coordination difficulties can be detected at an early age, whereas learning problems, attention deficits and other comorbid difficulties become gradually more evident as the children grow older/at school age (Hadders-Algra, 2002). Longitudinal studies indicate that children with the combination of severe motor difficulties, attention deficits and learning problems do not outgrow their problems, with negative social and psychological implications as a consequence (Cantell et al., 2003; Hadders-Algra, 2002; Hellgren et al. 1994; Losse et al., 1991; Rasmussen & Gillberg, 2000). Early identification of motor coordination difficulties, which in turn results in early intervention, may prevent the negative effects reported (Hadders-Algra, 2002; Losse et al., 1991; Missiuna et al., 2003). Research that highlights comorbidity between ADHD and motor coordination difficulties has increased recently (Piek et al., 1999; Pitcher et al., 2002; Tervo et al., 2002). There is, however, little information on possible co-occurrence between motor difficulties and ADHD /other types of behavioural and emotional problems in younger children (Kalff et al., 2003). In their study of 5-6 year old children, Kalff and collaborators (2003) investigated four groups (30 children later diagnosed with ADHD, 74 later diagnosed with borderline ADHD, 113 later diagnosed with other psychopathology and 126 healthy controls) on computerized motor control tasks involving low-and high-level controlled processing. They reported that the children at risk for ADHD were in general less accurate and more variable in their movements than children with other psychopathology and controls, and interpreted their findings as indicative of a specific deficit in high-level controlled processing in young children at risk for ADHD. In a recent study, Slaats-Willemse and collaborators (2005) suggested that higher-order controlled motor deficits in ADHD are associated with genetic susceptibility for ADHD.

In the present study we wanted to investigate incidence, severity and types of motor coordination problems in a group of children that displayed severe behavioural and emotional problems at the age of six,

and to compare this group with normally developing controls. We also wanted to investigate motor profiles on the M-ABC for children with different types of behavioural and emotional problems.

Method

Participants

Four girls and 25 boys with behavioural and emotional problems participated in the study. Their mean age was 6.35 years (SD 0.38). They were enrolled in a high-risk programme, carried out at a city school in Norway. Only eight children were included in the high-risk programme each year, and data were collected over a four-year period. The community had approximately 1200 6-year old children each year, out of which 10 to 12% were referred to the school psychology services (SPS) from school nurses, pre-school teachers and parents (Fitjar, leader of SPS, personal communication Sept. 27th, 2005). The preschool team at SPS decided, after thorough assessment, which children should be enrolled in the programme. Criteria for enrolment in the programme were severe behavioural and emotional problems, while children in need of more specific medical or neurological examination were excluded. None of the participating children had received any diagnosis for their problem behaviour. These children will be referred to as the high-risk group. The programme consisted of intensive daily training of cognitive, social and motor skills. The main idea was that the programme should prepare the children for full inclusion in ordinary classes at school.

The participants were assessed with the Wechsler Intelligence Scale for Children-Revised as a standard procedure (Undheim, 1978), which showed a mean total IQ of 84.79 (SD 16.95). Behaviour was assessed with the Teacher's Report Form, TRF, (Achenbach, 1991), and the group had a mean total T score of 68.41 (SD 7.60). A T- score of 63 is equivalent to the 90th centile, and a T-score of 70 points is equivalent to the 97.7th centile. The number of children who scored above the 95th centile on the eight subscales was as follows: Withdrawn 11, Somatic complaints 5, Anxious/Depressed 15, Social problems 22, Thought problems 12, Attention problems 14, Delinquent behaviour 10, and Aggressive behaviour 11. The control group was randomly drawn from a total sample of 83 children who had been tested with the M-ABC test as part of collection of Norwegian normative data for the age-group 5-6 years. The randomly drawn control group was matched with regard to gender. It consisted of 29 children (4 girls and 25 boys). The mean age of the children was 6.17 years (SD = 0.29). The children were reported by their parents to be in good health and without any specific diagnoses at school start. Intelligence testing and TRF evaluation was not carried out for the controls due to ethical considerations. The parents had allowed the M-ABC normative testing only and there was no legitimate reason to collect this kind of additional data. However, normal distribution of such data would be expected as the group consisted of randomly selected children from two typical and including Norwegian schools. The mean IQ level would accordingly be expected to be somewhat higher than in the high-risk group (about 100, as compared with 83.83).

Materials

In line with recommendations from Geuze et al. (2001), the Movement Assessment Battery for Children (M-ABC) (Henderson & Sugden, 1992), a broad and norm-based standardized measure, was chosen for evaluation of motor coordination difficulties. The M-ABC is widely used in Europe for research purposes as well as a clinical tool. It is a comprehensive assessment battery consisting of the M-ABC Checklist, the M-ABC Test and guidelines for remediation. Only the M-ABC Test was used in this study. The M-ABC Test yields an overall motor impairment score indicating increasingly pronounced motor difficulties with increasing scores. There are sub-scores for the areas manual dexterity, ball skills and balance as well as sub-test scores within these areas. The test consists of 8 different test-items, yielding ordinal data on a scale from 0-5, with 5 indicating severe motor difficulties on the particular item and 0 indicating no problems. The M-ABC is designed to detect difficulties, not to differentiate between average and superior motor performance. Only small non-significant differences have been reported with regard to gender differences (Henderson & Sugden, 1992).

Formal standardization of the M-ABC test has not been carried out in Norway. However, in her study of 360 9-10 year old children Mæland (1992) concluded that the original norms were appropriate for Norwegian children. In line with the original standardization data, she reported only small, non-significant differences between boys and girls. In a cross-cultural comparison of two matched groups of 6-year old American and Swedish children, Rösblad and Gard (1998) concluded that the norms were appropriate for Swedish children. According to the manual, overall reliability is good, ranging from 97 % in 5-year-old children to 73 % in 9- year-olds. The M-ABC is a modification of the Test of Motor Impairment (Stott et al., 1984), and Henderson and Sugden (1992) stated that the evidence supporting the sound psychometric properties of the TOMI could be generalized to the M-ABC.

As a second step of assessment, the motor function of the children who obtained borderline or clinical motor impairment scores on the M-ABC were further evaluated at the ICF levels of activity and participation (WHO, 2001). The teachers observed the children during performance of the following chosen target skills over a period of two weeks: Running, jumping, climbing, riding a bike, drawing, and dressing and outdoor play. The teachers also obtained additional parental information regarding motor function through informal interviews. The teachers' observations and notes were then discussed with experienced paediatric physiotherapists who had observed the children on several occasions, and they agreed whether the children performed the target skills as would be expected according to age, or showed borderline or definite difficulties during performance.

Procedure

The study was administered in accordance with the guidelines of the Declaration of Helsinki. Participation was based on written informed consent. For the high-risk group, 31 out of 32 possible permissions were obtained. All parents of the first-graders in the control group allowed their children to participate. During assessment, 2 children from the high-risk group had difficulties performing the M-ABC due to cognitive deficits. Reports and observations confirmed moderate mental retardation for these children,

and they were therefore excluded from the sample. Reported indications of cognitive delay (total IQ score below 70) in three additional children in the high-risk group were not confirmed through assessment of the children's overall responses and behaviour, and they performed adequately during assessment. These children were therefore included in the sample. The final sample consisted of 29 children (4 girls, 25 boys) in the high-risk group, and the control group was matched to this.

Both groups were assessed at their local schools by experienced paediatric physiotherapists, following the administration procedures described in the test-manual. In order to enhance inter-tester reliability, the three physiotherapists undertook joint preparatory video-analyses of testing-procedures and scoring.

Analyses

Statistical analyses were done using the SPSS, version 13. The motor skills in the high-risk group were not normally distributed, and the non-parametric, two-tailed Mann-Whitney U-Tests and Spearman rho correlations were therefore chosen. As only four girls were included in each group, the analyses were done without splitting the groups by gender.

Results

Incidence, severity and types of motor coordination difficulties as assessed with the Movement ABC

The high-risk group obtained a mean total score of 14.19 (SD 9.35) on the M-ABC, which is slightly below the 5th centile. The individual results varied from 0, indicating normal motor skills, to 28, indicating severe problems. The mean total score was 5.29 (SD 4.22) in the control group, or close to 45th centile, with individual results varying from 0 to 15. The difference between the groups was significant ($p < .001$).

The mean M-ABC results from the sub-areas manual dexterity, ball skills, and balance can be seen in Figure 1.

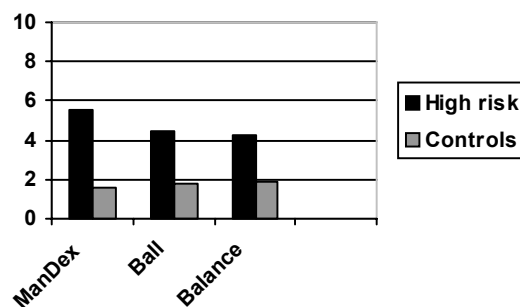


Figure 1: Mean sub-area scores at the M-ABC for the high risk group (n=29) and the control group (n=29)

ManDex: Comprises the sum-score of 3 items in the sub-area of manual dexterity

Ball: Comprises the sum-score of 2 items in the sub-area of ball-skills

Balance: Comprises the sum-score of 3 items in the sub-area of balance

The figure illustrates that the high-risk group displayed more problems than the control group. The differences between the groups were significant in all three areas (manual dexterity high-risk 5.53 (SD 4.43), controls 1.59 (SD 2.20): $p < .001$, ball skills high-risk 4.43 (SD 3.11) controls 1.83 (SD 1.81): $p < .002$, and balance high-risk 4.24 (SD 3.75) controls 1.88 (SD 2.54): $p < .005$).

The mean test results for the two groups regarding the eight sub-tests are presented in Table 1. Standard deviations are also included.

Table 1: Mean subscale-scores at the M-ABC for the high-risk group (n=29) and the control group (n=29).

	High- risk group	Control group	p-value
ManDex 1	1.53 (SD 1.40)	0.50 (SD 0.72)	.002
ManDex 2	2.03 (SD 1.84)	0.74 (SD 1.30)	.001
ManDex 3	1.93 (SD 2.00)	0.34 (SD 0.72)	.001
Ball skills 1	1.91 (SD 1.91)	0.59 (SD 1.12)	.004
Ball skills 2	2.52 (SD 1.96)	1.24 (SD 1.27)	.016
Balance 1	1.76 (SD 1.68)	0.33 (SD 0.67)	.000
Balance 2	1.21 (SD 1.93)	1.52 (SD 2.15)	.ns
Balance 3	1.28 (SD 1.65)	0.03 (SD 0.19)	.000

As can be seen from the table, the difference between the two groups was significant for seven of the eight sub-tests. The exception was Balance 2, measuring explosive, dynamic balance.

With regard to types of difficulties, Figure 2 illustrates a mixed motor impairment profile for the high-risk group, with difficulties in all sub-areas and test-items.

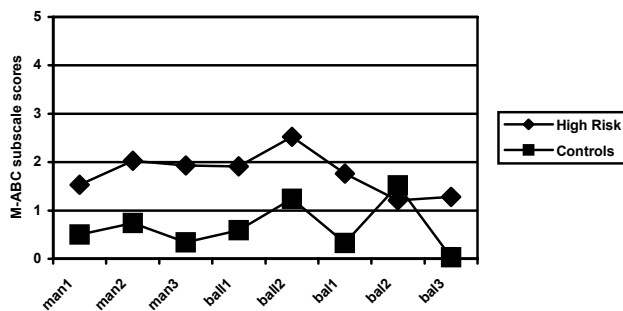


Figure 2: Mean subscale scores for the individual eight test-items at M-ABC for the high risk group (n=29) and the control group (n=29)

The figure also illustrates that the highest mean sub-test score in the control group was test-item Balance 2, indicating that this particular item was the most difficult item for the control group. The high-risk group showed an opposite pattern.

Regarding individual test results, the number and percentage of children showing normal motor function (total score > 15 centile), borderline function (> 5 to ≤ 15 centile), and definite motor problems (≤ 5 centile) are presented in Table 2.

Table 2: Number and percentage of children in the high risk group (n=29) and control group (n=29) who obtained total M-ABC scores at a clinical level (≤ 5 centile), borderline level (> 5 to ≤ 15 centile) or at a normal level (> 15 centile).

	High risk group	Control group
Clinical scores	16 (55.2 %)	3 (10.3 %)
Borderline scores	2 (6.9 %)	3 (10.3 %)
Normal scores	11 (37.9 %)	23 (79.3 %)

As can be seen from Table 2, more than half of the children in the high-risk group obtained a total motor impairment score at a clinical level at or below the 5th centile for which motor intervention is recommended (Henderson and Sugden, 1992). The individual total M-ABC scores for all children are presented in Table 3, and it can be seen that the patterns were clearly different between the high-risk group and controls.

Table 3: Total individual M-ABC scores in the clinical, borderline and normal area for the high-risk (HR) group and controls (C).

	Clinical scores		Borderline		Normal	
	HR	C	HR	C	HR	C
1	28	15	12.5	11	9	8
2	27.5	14	10	10	6	6.5
3	26.5	13.5		10	6	6
4	26				5	6
5	26				4.5	5
6	25.5				4	5
7	24.5				4	4.5
8	23				2.5	4.5
9	21.5				2	4
10	18.5				1	4
11	18				0	4
12	17.5					4
13	17					4
14	16.5					3.5
15	15					3.5
16	14					3
17						1
18						1
19						1
20						1
21						1
22						0.5
23						0

To look for possible relationships between sub-areas of behaviour and emotional problems and types of motor difficulties, the high-risk group was divided in sub-groups on the basis of various TRF sub-

scores. The children were allocated in the various sub-groups based on scores in the borderline area or worse, or above the borderline area. The groups were then compared with regard to total M-ABC scores, manual dexterity, ball skills and balance. Sub-division on the basis of externalizing behaviour showed that there was a clinically significant difference regarding mean manual dexterity scores (16 children versus 13, mean scores 6.9 versus 3.8), but this did not reach statistical significance ($p = .065$). Sub-division on the basis of internalizing behaviour yielded no clinical or statistical differences. Sub-division was also done on the basis of the TRF sub-scale scores Anxiety, Social and Attention. These scales were selected because they identified most children with social and emotional problems, as reported in the method section. Sub-division on the basis of Attention yielded a statistically significant difference between the groups with regard to manual dexterity. Children with attention problems performed much worse than those without (14 children versus 15, mean scores 7.2 versus 3.8, $p = .020$, Spearman rho = .40). The Manual Dexterity sum-score comprises three individual test-items, and further analyses showed that test-item 3 stood out as particular difficult for the children with attention problems, with a mean subscale score of 3.2 as compared to 0.8 for the children without borderline or clinical attention difficulties. Manual Dexterity 3 consists of drawing a continuous line within defined borders, thus resembling the task of writing. Sub-division on the Social scale also yielded a clinically significant difference between mean manual dexterity scores (22 children versus 7, mean scores 6.4 versus 2.6), but this did not reach statistical significance ($p = .059$). There was also a clinically noticeable difference between the groups on the total mean M-ABC scores (15.8 equivalent to the 3rd centile versus 9.2 equivalent to the 17th centile). Sub-division on the basis of the Anxiety scale yielded no clinical or statistical significant differences.

The high-risk group was also sub-divided on the basis of IQ-scores in order to check for possible differences, where one group scored IQ 85 or lower and the other above IQ 85. This yielded 15 children in the first group with a mean total M-ABC score of 13.7 and 14 children with a mean score of 14.7 in the other. (Spearman rho correlation between total M-ABC score and full scale IQ = .039)

Motor assessment at the functional levels of activity and participation

Teacher observations of the 18 children from the high-risk group who obtained motor impairment scores at or below the 15th centile, confirmed motor difficulties as assessed with systematic observation at the level of activity and participation for all these children, thus fulfilling criterion B of the DSM-IV. However, the teachers reported that during observation of complex motor skills, such as outdoor play, it was very difficult and often not possible to differentiate between motor and behavioural aspects. In the control group, the 6 children who scored at or below the 15th centile at the M-ABC were further evaluated. The child with the highest M-ABC score at 15 was reported by the teacher and confirmed by the parents to display difficulties at activities such as running, jumping, climbing and outdoor play. With regard to fine motor activities, he performed as expected for his age. Additional clinical physiotherapy assessment confirmed definite gross motor problems for this child, supported by the child's individual M-ABC profile

(Manual index 1.5, Ball Skills 6, Balance 7.5). The other 2 children with scores below the 5th centile obtained motor impairment scores close to a borderline level, and teachers and parents reported that they did not exhibit substantial problems during daily performance of motor skills. None of the 3 children with a total impairment score at borderline level exhibited substantial problems during daily activities. As such, these children did not fulfill criterion B with regard to a DCD diagnosis.

Table 4 summarizes the number and percentage of children who fulfilled the criteria of the DSM-IV (APA, 1994) for the DCD diagnosis.

Table 4: The number and percentage of children in the high-risk group (n=29) and the control group (n=45) who fulfilled the diagnostic criteria A and B of the DSM-IV (APA, 1994) for the diagnosis developmental coordination disorder.

Criterion A: Total motor impairment score at or below the 5th centile

Criterion B: Confirmation of significant motor problems based on observation at school

	High risk group	Control group
Criterion A	16 (55.2 %)	3 (10.3 %)
Criterion B	16 (55.2 %)	1 (3.4 %)

In their review of literature, Geuze et al. (2001) discussed whether a total motor impairment score corresponding to the 15th or the 5th centile should be used as cut-off point during evaluation of criterion A of the DSM-IV (APA, 1994). As can be seen from Table 4, we chose a cut-off point at the 5th centile, corresponding to a clinical level. Note that fulfillment of criteria C was reported in the method section during the description of participant characteristics, as only children without medical or neurological diagnoses were included in the study. With regard to criterion D, a total IQ at or below 70 is considered indicative of mental retardation. As described in the method section, we included 3 children in the high-risk group with IQ below 70, as mental retardation was not confirmed through their overall responses and behaviour.

Discussion

This study demonstrates that there is a strong degree of co-occurrence between motor coordination difficulties and severe behavioral and emotional problems in 5-6 year-old children. We would however, underscore that the children in the high-risk group represent the most severe cases of problem behavior, as assessed with the Teacher's Report Form (Achenbach, 1991). The results must be evaluated bearing this in mind. A limited sample size must also be considered when the results are evaluated. A further limitation to the study is the lack of parental reports of behaviour and emotional problems in the high-risk group, such as CBCL assessment (Achenbach, 1991). However, as reported in the method section, the children in the high-

risk group were carefully selected by the school psychology service, based on ample information from parents and pre-school teachers, as well as formal assessment by the SPS.

The motor assessment was conducted with a recommended standardized test. In order to evaluate motor function at a broad functional level, as recommended by Rodger et al. (2003), including criterion B of the DSM-IV, we supplemented the formal testing with systematic observation. Trained and experienced paediatric physiotherapists, in familiar school-surroundings, carried out the formal assessments. Teachers who were familiar to the children carried out the systematic observation in a natural environment. It must however, be emphasized that assessment of this particular group of children is a challenge, and that the results always must be interpreted with care.

Three children with IQ below 70 from the high-risk group were included in the study, because mental retardation was not confirmed through observation and additional assessment. They also performed adequately when tested with the M-ABC. Intelligence testing of young children with severe behaviour problems is a challenge, and when in doubt, results should be confirmed by other sources (Kaufman, 1994).

The finding that more than half of a group of young children with behavioral and emotional problems also fulfill the diagnostic criteria for developmental coordination disorder at the DSM-IV (APA, 1994), underscores the importance of multidisciplinary assessment of this group of children in order to screen for possible motor difficulties. As children with severe behavioral and emotional problems traditionally are assessed within educational/psychiatric settings, motor difficulties may easily be overlooked.

The frequency of definite and borderline motor problems in the control group was as expected on the basis of normative data, with a mean total M-ABC score in line with the original standardization data. This lends support to the fact that the original norms for 5 -6 year-olds are acceptable also for Norwegian children.

The results from this study are in accordance with other studies that point to comorbidity of developmental disorders as common. Recent studies of children with ADHD have shown a frequent overlap with motor coordination problems (Kadesjö & Gillberg, 1998; Kalff et al., 2003; Landgren et al., 1998; Piek et al., 1999; Pitcher et al., 2002; Slaats-Willemse et al., 2005; Tervo et al., 2002). Frequent motor difficulties have also been reported in children with reading difficulties and dyslexia (Iversen et al., 2005a, Jongmans et al., 2003; Kaplan et al., 1998; Nicolson & Fawcett, 1999; Nicolson et al., 2001; Ramus et al., 2003).

With respect to types of motor coordination difficulties, the results showed mixed profiles, with difficulties in all sub-areas, as measured by the M-ABC. As shown in Figure 2, the only non-significance found (Balance 2, explosive dynamic balance), was caused by a higher score in the control group, and not due to lesser problems in the high-risk group. The findings of mixed profiles indicates that the children with motor coordination difficulties in the high-risk group were characterized by general motor difficulties, affecting manual dexterity as well as gross motor function. However, as emphasized by Jongmans et al. (2003) and Cermak et al. (2002), children with DCD is a mixed and heterogeneous group, and specific

individual motor profiles need to be established in order to optimize and adapt intervention for each particular child.

Our findings of a significant relationship between children with severe attention problems and manual dexterity difficulties on the M-ABC underscore the importance of careful individual motor assessment. This finding is in line with earlier reports of a high rate of fine motor difficulties in 5-6 year old children at risk for ADHD (Kalff et al., 2005). The fact that the most difficult individual test-item was Manual Dexterity 3, or drawing a continuous line between defined borders, also supports the findings of Kalff et al. (2003). The task requires continuous attention and adjustment of movements, and imposes substantial executive function demands.

Schoemaker and Kalverboer (1994) showed that children make comparisons based on motor competence as early as the age of 6, and reported that children with movement problems were more introverted and anxious compared to normal controls. Children with movement difficulties have been reported to spend significantly more time alone than their peers (Bouffard et al., 1996; Smyth & Anderson, 2000). In this study, the behavioural and emotional difficulties of the children in the high-risk group seemed to enhance motor coordination difficulties at activity and participation level negatively. While all the children in the high-risk group who obtained motor impairment scores at a borderline or clinical level also showed significant motor difficulties during activities of daily living (criterion B of the DSM-IV), only 1 of 6 children in the control group fulfilled this additional criteria.

The fact that only 1 of 6 children in the control group with borderline or clinical problems assessed with the M-ABC showed significant motor problems during observation of daily functional activities warrants an additional comment. In a report by Rodger et al. (2003) they argue that motor function needs to be evaluated within a broad functional framework for young children suspect of DCD. Our findings support the application of such broad frameworks as important in order to apply adequate evaluation strategies for this group of children.

The combination of clinical behavioural and emotional problems and DCD makes the children vulnerable with respect to social function and participation in culturally valued motor skills. Their motor difficulties can easily increase an already substantial risk of social exclusion. Or, reversing the angle, a choice of intervention which focuses on learning important motor skills such as riding a bike, swimming, climbing, skateboarding, diving and so on (the choice of activities depending on local culture and individual interests and motivation), could possibly improve the children's possibilities for social inclusion (Missiuna et al. 2003; Shoemaker et al., 1994). Recent research, which point to targeted motor skills approaches in motor intervention as superior to general motor training approaches, adds support to this suggestion (Iversen et al., 2005b; Mandich et al., 2001; Miller et al., 2001; Missiuna et al., 2003; Pless and Carlson, 2000; Sigmundsson et al., 1998; Wright and Sugden, 1998).

Due to the complexity of the children's problems, it is likely that multidisciplinary teamwork on site at kindergartens/schools, with the aim of providing local support and help to teachers and parents could increase the possibilities of successful intervention. Evaluations of multidisciplinary on-site team-work at

first grade level, which included help from physio- and occupational therapists, school-nurses and the school psychology services, showed that this type of teamwork improved quality of intervention and promoted inclusive education for children with special needs (Iversen, et al., 2006).

Conclusion

In this study, 62.1 % of a group of children with severe behavioral and emotional problems showed borderline or definite motor coordination difficulties as assessed with the Movement Assessment Battery for Children, compared to 20.7 % of the children in the control group. Based on further assessment at the functional levels of activity and participation, 55.2 % of the children in the high-risk group fulfilled the criteria of the DSM- IV (APA 1994) warranting a diagnosis of developmental coordination disorder, compared to 3.4 % of the children in the control group. The majority of the children in the high-risk group showed mixed motor profiles, with fine- as well as gross motor difficulties. When motor profiles for children with specific types of behavioural and emotional difficulties were investigated, a significant relationship was detected between attention problems and manual dexterity difficulties. The combination of severe behavioral and emotional problems and motor coordination difficulties makes this group of children particularly vulnerable with regard to participation in culturally valued motor skills. The children's motor coordination problems could easily increase an already substantial risk for social exclusion, with implications for assessment and choice of intervention strategies.

References

- Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist/4-18 and 1991 Profile*. Burlington, VT: University of Vermont Department of Psychiatry.
- Achenbach, T. M. (1991). *Manual for the Teacher's Report Form and 1991 Profile* (Burlington, VT, University of Vermont Department of Psychiatry).
- American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed (DSM-IV) (Washington DC, American Psychiatric Press).
- Bax, M. (1999). Specific learning disorders/neurodevelopmental disorders, *Developmental Medicine and Child Neurology*, 41, pp. 147.
- Bouffard, M., Watkinson, E.J., Thompson L.P., Causgrove Dunn, J.L. & Romanow, S.K.E. (1996). A test of the activity deficit hypothesis with children with movements difficulties, *Adapted Physical Activity Quarterly*, 13, pp. 61-73.
- Campbell, S. B. (1990). *Behavior problems in preschool children: clinical and developmental issues* (New York, Guilford Press).
- Campbell, S. B. (1995). Behavior problems in preschool children: A review of recent research, *Journal of Child Psychology and Psychiatry*, 36, pp. 113-149.
- Cantell, M.H., Smyth, M.M. & Ahonen, T.P. (2003). Two distinct pathways for developmental coordination disorder: Persistence and resolution, *Human Movement Science*, 17, pp. 413-431.
- Cantwell, D. P., Baker, L. & Mattison, R. E. (1979) The prevalence of psychiatric disorder in children with speech and language disorder: An epidemiological study, *Journal of the American Academy of Child Psychiatry*, 18, pp. 450-461.
- Cermak, S.A., Gubbay, S.S. & Larkin, D. (2002). What is Developmental Coordination Disorder?, in: S.A. Cermak and D. Larkin (Eds.) *Developmental Coordination Disorder* (Albany, NY, Delmar Thomson Learning), pp. 2- 22.
- Cohen, D. A., Davine, M. & Meloche-Kelly, M. (1989). The prevalence of unsuspected language disorders in a child psychiatric population, *American Academy Journal of Child and Adolescent Psychiatry*, 28, pp. 107-111.
- 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, pp. 905-918.
- Geuze R.H., Jongmans, M.J., Schoemaker, M.M. & Smits-Engelsman, B.C.M. (2001). Clinical and research diagnostic criteria for developmental coordination disorder: a review and discussion, *Human Movement Science*, 20, pp. 7-47.
- Goodman, R. & Scott, S. (1997). *Child Psychiatry* (Oxford, Blackwell Science).
- Hadders-Algra, M. (2002). Two distinct forms of minor neurological dysfunction: perspectives emerging from a review of the Groningen perinatal project, *Developmental Medicine and Child Neurology*, 44, pp. 561-571.
- Hay, J. & Missiuna, C. (1998). Motor proficiency in children reporting low levels of participation in physical activity, *Canadian Journal of Occupational Therapy*, 65, pp. 64-71.

Hellgren, L., Gillberg, I.C., Bågenholm, A. & Gillberg, C. (1994). Children with deficits in attention, motor control and perception (DAMP) almost grown up: Psychiatric and personality disorders at age 16 years, *Journal of Child Psychology and Psychiatry*, 35, pp.1255-1271.

Henderson, L., Rose L. & Henderson, S.E. (1992). Reaction time and movement time in children with developmental coordination disorder, *Journal of Child Psychology and Psychiatry*, 33, pp. 895-905.

Henderson, S.E. & Sugden, D.A. (1992). *Movement Assessment Battery for Children* (Kent, The Psychological Corporation).

Henderson, S.E. & Barnett, A.L. (1998). The classification of specific motor coordination disorders in children: some problems to be solved, *Human Movement Science*, 17, pp. 449-469.

Iversen, S., Berg, K. Ellertsen, B & Tønnesen, F.E. (2005a). Motor coordination difficulties in a municipality group and in a clinical sample of poor readers, *Dyslexia*, 11, pp. 217-231.

Iversen, S., Ellertsen, B., Tytlandsvik, A. & Nødland, M. (2005b). Intervention for 6 year-old children with motor coordination difficulties: Parental perspectives at follow-up in middle childhood, *Advances in Physiotherapy*, 7, pp. 67-76.

Iversen, S., Ellertsen, B., Jacobsen, S.R., Råheim, M. & Knivsberg, A.M. (2006). Developing a participatory multidisciplinary team approach to enhance the quality of school start, *Action Research*, 4, pp.271-292.

Jongmans, M.J., Smits-Engelsman, B.C.M. & Shoemaker M.M. (2003). Consequences of comorbidity of developmental coordination disorders and learning disabilities for severity and pattern of perceptual-motor dysfunction, *Journal of Learning Disabilities*, 36, pp. 528-537.

Kadesjö, B. & Gillberg, C. (1998). Attention deficits and clumsiness in Swedish 7-year-old children, *Developmental Medicine and Child Neurology*, 40, pp.796-804.

Kalff, A.C., de Sonnevile, L.M.J., Hurks, P.P.M., Hendriksen, J.G.M., Kroes, M., Feron, F.J.M., Steyart, J., van Zeben, T.M:C.B., Vles, J.S.H. & Jolles, J. (2003). Low-and high-level controlled processing in executive motor control tasks in 5-6-year-old children at risk for ADHD, *Journal of Child Psychology and Psychiatry*, 44, pp.1049-1057.

Kaplan, B.J., Wilson, B.N., Dewey, D. & Crawford, S.G. (1998). DCD may not be a discrete disorder, *Human Movement Science*, 17, pp. 471-490.

Kaufman, A.S. (1994) *Intelligent testing with the WISC-III* (Indianapolis, John Wiley & Sons).

Keenan, K., Shaw, D., Delliquadri, E., Giovannelli, J. & Walsh, B. (1998). Evidence for the continuity of early problem behaviors: Application of a developmental model, *Journal of Abnormal Psychology*, 26, pp. 441-452.

Landgren, M., Kjellman, B. & Gillberg, C. (1998). Attention deficit disorder with developmental coordination disorder, *Archives of Disease in Childhood*, 79, pp. 207-212.

Landgren, M., Kjellman, B. & Gillberg, C. (2000). Deficits in attention, motor control and perception (DAMP): a simplified school entry examination, *Acta Paediatrica*, 89, pp. 302-309.

Losse, A., Henderson, S.E., Elliman, D, Hall, D, Knight, E. & Jongmans, M. (1991). Clumsiness in children – do they grow out of it? A 10-year follow-up study, *Developmental Medicine and Child Neurology*, 33, pp. 55-68.

- Mandich, A.D., Polatajko, H.J., Macnab, J.J. & Miller, L.T. (2001). Treatment of children with developmental coordination disorder: what is the evidence? *Physical and Occupational Therapy in Pediatrics*, 20, pp. 51-68.
- McGee, R., Partridge, F., Williams, S. & Silva, P. A. (1991). A twelve year follow-up of preschool hyperactive children, *Journal of the American Academy of Child and Adolescent Psychiatry*, 30, pp. 224-232.
- Miller, L.T., Polatajko, H.J., Missiuna, C., Mandich, A.D. & Macnab, J.J. (2001). A pilot trial of cognitive treatment for children with developmental coordination disorder, *Human Movement Science*, 20, pp. 183-210.
- Missiuna, C. and Polatajko, H. (1995). Developmental dyspraxia by any other name: are they all just clumsy children? *American Journal of Occupational Therapy*, 49, pp. 619-627.
- Missiuna, C., Rivard, L. & Bartlett, D. (2003) Early identification and risk management of children with developmental coordination disorder, *Pediatric Physical Therapy*, 15, pp.32-38.
- Mæland, A. F. (1992). Identification of children with motor coordination problems, *Adapted Physical Activity Quarterly*, 9, pp. 330-342.
- Nicolson, R.I. & Fawcett, A.J. (1999). Developmental dyslexia: The role of the cerebellum, *Dyslexia*, 5, pp. 155-177.
- Nicolson, R.I., Fawcett, A. & Dean, P. (2001). Dyslexia, development and the cerebellum, *Trends in Neurosciences*, 24, pp. 508-511.
- Newth, S. J. & Corbett, J. (1993). Behaviour and emotional problems in three-year-old children of Asian parentage, *Journal of Child Psychology and Psychiatry*, 34, pp. 333-352.
- O'Beirne, C., Larkin, D. & Cable, T. (1994). Coordination problems and anaerobic performance in children, *Adapted Physical Activity Quarterly*, 11, pp. 141-149.
- Ogden, T. (2002). *Sosial kompetanse og problematferd i skolen. Kompetanseutviklende og problemløsende arbeid i skolen* (Oslo, Gyldendal Norsk Forlag).
- Piek, J.P., Pitcher, T.M. & Hay, D.A. (1999). Motor coordination and kinaesthesia in boys with attention-deficit-hyperactivity-disorder, *Developmental Medicine and Child Neurology*, 41, pp. 159-165.
- Pierce, E. W., Ewing, L. J. & Campbell, S. B. (1999). Diagnostic status and symptomatic behavior of hard-to-manage preschool children in middle childhood and early adolescence, *Journal of Clinical Child Psychology*, 28, pp. 44-57.
- Pitcher, T.M., Piek, J.P. & Barrett, N.C. (2002). Timing and force control in boys with attention deficit hyperactivity disorder: subtype differences and the effect of comorbid developmental coordination disorder, *Human Movement Science*, 21, pp. 919-945.
- Pless, M. & Carlsson, M. (2000). Effects of motor skill intervention on developmental co-ordination disorder: A meta-analysis, *Adapted Physical Activity Quarterly*, 17, pp. 381-401.
- Polatajko, H.J., Fox, M. & Missiuna, C. (1995). An international consensus on children with developmental coordination disorder, *Canadian Journal of Occupational Therapy*, 62, pp. 4-6.
- Ramus, R., Pidgeon, E. & Frith, U. (2003). The relationship between motor control and phonology in dyslexic children, *Journal of Child Psychology and Psychiatry*, 44, pp. 712-722.

Rasmussen, P. & Gillberg, C. (2000). Natural outcome of ADHD with developmental coordination disorder at age 22 years: a controlled, longitudinal, community-based study, *Journal of the American Academy of Child and Adolescent Psychiatry*, 39, pp. 1424-1431.

Raynor, A.J. (2001). Strength, power and co-activation in children with developmental coordination disorder, *Developmental Medicine and Child Neurology*, 43, pp. 676-684.

Richardson, A.J. and Ross, M.A. (2000). Fatty acid metabolism in neurodevelopmental disorder: a new perspective on associations between attention-deficit/hyperactivity disorder, dyslexia, dyspraxia and the autistic spectrum, *Prostaglandins, Leukotrienes and Essential Fatty Acids*, 63, pp. 1-9.

Rodger, S., Ziviani, J., Watter, P., Ozanne, A., Woodyatt, G. & Springfield, E. (2003). Motor and functional skills of children with developmental coordination disorder: A pilot investigation of measurement issues, *Human Movement Science*, 17, pp. 461-478.

Rösblad, B. & von Hofsten, C. (1994). Repetitive goal-directed arm movements in children with developmental coordination disorders: Role of visual information, *Adapted Physical Activity Quarterly*, 11, pp. 190-202.

Rösblad, B. & Gard, L. (1998). The assessment of children with Developmental Coordination Disorders in Sweden: A preliminary investigation of the suitability of the Movement ABC, *Human Movement Science*, 17, pp. 711-719.

Schoemaker, M.M. & Kalverboer, A.F. (1994). Social and affective problems of children who are clumsy: How early do they begin? *Adapted Physical Activity Quarterly*, 11, pp. 131-140.

Schoemaker, M.M., Hijlkema, M.G.J. & Kalverboer, A.F. (1994). Physiotherapy for clumsy children – an evaluation study, *Developmental Medicine and Child Neurology*, 36, pp. 143-155.

Sigmundsson, M.D., Pedersen, A.V., Whiting, H.T.A. & Ingvaldsen, R.P. (1998). We can cure your child's clumsiness! A review of intervention methods, *Scandinavian Journal of Rehabilitation and Medicine*, 30, pp. 101-106.

Slaats-Willemse, D., de Sonnevile, L., Swaab-Barneweld H., & Buitelaar J. (2005). Motor flexibility problems as a marker for genetic susceptibility to attention-deficit/hyperactivity disorder. *Biological Psychiatry*, 58, pp. 233-238.

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

Stott, D.H., Moyes, F.A., & Henderson, S.E. (1984). *The Henderson revision of the Test of Motor Impairment*. San Antonio: The Psychological Corporation.

Sugden, D.A. & Wright, H.C. (1998). *Motor Coordination Disorders in Children* (Thousand Oaks, CA, Sage Publications, Inc.).

Tervo, R.C, Azuma, S., Fogas, B. & Fiechtner, H. (2002). Children with ADHD and motor dysfunction compared with children with ADHD only, *Developmental Medicine and Child Neurology*, 44, pp. 383-390.

Undheim, J. O. (1978). *Håndbok for Wechsler Intelligence Scale for Children – Revised* (Oslo, Norsk Psykologforening).

Visser, J. (2003) Developmental coordination disorder: a review of research on subtypes and comorbidities, *Human Movement Science*, 22, pp. 479-493.

White, J., Moffitt, T. E., Earls, F., Robins, L. & Silva, P. A. (1990) How early can we tell. Predictors of childhood conduct disorder and adolescent delinquency, *Criminology*, 28, pp. 507-533.

Wilson, P.H. & McKenzie, B.E. (1998). Information processing deficits associated with developmental coordination disorder: A meta-analysis of research findings, *Journal of Child Psychology and Psychiatry*, 39, pp. 829-840.

World Health Organization (2001). *International classification of functioning, disability and health* (Geneva, World Health Organization).

Wright, H.C. & Sugden, D.A. (1998). A school based intervention programme for children with developmental coordination disorder, *European Journal of Physical Education*, 3, pp. 35-50.