Developmental Co-ordination Disorder in Pre-School Children

Effects of Motor Skill Intervention, Parents' Descriptions, and Short-Term Follow-Up of Motor Status

BY

MIA PLESS
**ABSTRACT**


This investigation was undertaken to examine effects of motor skill intervention in children with motor difficulties consistent with developmental co-ordination disorder (DCD) diagnosed in child health care before school entrance, to analyse the parents’ descriptions of their children, and to follow up the children’s motor status in a short-term perspective.

Thirteen studies on effects of motor skill intervention were submitted to a meta-analysis (Study I). Thirty-seven children who at age 5 to 6 years were diagnosed as having motor difficulties consistent with DCD were enrolled in an experimental investigation of effects of group motor skill intervention on motor skills (Study II) and on self-perceived competence (Study III). The parents’ descriptions of their children were obtained at an interview (Study IV). The children’s motor status was re-examined when they were 7 to 8 years old (Study V).

Motor skill intervention, using the Specific Skills approach, in a group setting or in a home programme, 3 to 5 times per week, was found beneficial for children with DCD who were older than 5 years of age. The non-specific group motor skill intervention influenced the number of children with borderline motor difficulties who changed to having no motor difficulties, and seemed to enhance awareness of motor competence. Parents whose children had definite motor difficulties were more inclined to support their children in physical activity, and reported worry and uncertainty. The children had not changed their motor status at the age of 7 to 8 years. The children with definite motor difficulties, in particular, continued to have these difficulties. Children who when 5 to 6 years old have motor difficulties and who score at the 5th percentile or below at the Movement ABC motor test, seem to need active support in joyful motor learning situations to reduce unwillingness and displeasure.

**Key words**: Developmental co-ordination disorder, follow-up, motor skill intervention, pre-school children, self-perceived competence.

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I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.

Just so stories
Rudyard Kipling, 1902 (p. 91)
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THESIS

This dissertation is based on the following studies, which are referred to by their Roman numerals:

I. Pless M. Carlsson M.
   Effects of motor skill intervention on developmental co-ordination disorder: A meta-analysis. Adapted Physical Activity Quarterly 2000; 17:381-401

II. Pless M. Carlsson M. Sundelin C. Persson K.

III. Pless M. Carlsson M. Sundelin C. Persson K.
     Pre-school children with developmental co-ordination disorder: Self-perceived competence and group motor skill intervention, in press

IV. Pless M. Persson K. Sundelin C. Carlsson M.
    Children with developmental co-ordination disorder: A qualitative study of parents’ descriptions, accepted

V. Pless M. Carlsson M. Sundelin C. Persson K.
    Pre-school children with developmental co-ordination disorder: short-term follow-up of motor status at age 7 to 8 years, submitted

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ABBREVIATIONS

ADHD = Attention Deficit Hyperactivity Disorder

APA = American Psychiatric Association

CHC = Child Health Centre

DCD = Developmental Co-ordination Disorder

DSM IV = Diagnostic Statistical Manual, 4th edition

ES = Effect Size

GA = General Abilities (theoretical approach)

MES = Mean Effect Size

PMC = Perceived Motor Competence (scale)

SI = Sensory Integration (theoretical approach)

SS = Specific Skills (theoretical approach)
ERRATA

p.7 fifth line  
SAYS: Diagnostic Statistical Manual  
SHOULD BE: Diagnostic Statistical Manual of Mental Disorders

p.19 table I, Study II, Instruments/ tests  
SAYS: Observation of participation in training.  
SHOULD BE: Observation Scheme for participation in intervention.

p.27 last paragraph, 5th line  
SAYS: (44, 48, 51, 60, 83)  

p.29 first paragraph, 5th line  
SAYS: (95)  

p.32 second paragraph, 5th line  
SAYS: (11, 19, 37, 60)  
SHOULD BE: (11, 19, 37, 61)
INTRODUCTION

Developmental screening and surveillance
Developmental screening consists in a routine examination of all children, and includes family factors and social circumstances as well as the child’s performance in developmental tasks. The term surveillance is also used, and this encompasses all secondary prevention activity such as routine health checks, population screening and health education (29). Screening tests are expected to discriminate children at high risk from those at low risk of having a developmental abnormality or disorder (85). Permanent, severely disabling conditions are relatively uncommon, and professionals working in child health centres (CHC) have gradually turned their attention to developmental impairments such as language and speech delay, clumsiness and behavioural problems. The difficulty in identifying children who are likely to benefit from various forms of intervention is a matter of much concern, but it is also important to elucidate the possible effects of different interventions and to be able to predict whether the children’s difficulties are likely to persist (29). Identification of children with motor difficulties is one of the goals of developmental screening, and motor skill intervention is often recommended (18).

Developmental co-ordination disorder
Children with motor difficulties may have been diagnosed previously as having delayed motor development, clumsiness, perceptual motor dysfunction, poor motor co-ordination, physical awkwardness or minor neurological dysfunction (15, 41, 46, 54). These terms have all been used to describe developmental delays in children that cannot be explained by a known medical condition, environmental factors or mental retardation. There is no very obvious reason for these children’s difficulties. Nevertheless, they find it hard to acquire the motor skills they need to function adequately in everyday life (4). According to the Diagnostic and Statistical Manual of Mental Disorders, DSM IV (1) the diagnosis in children with such developmental delays is Developmental Co-ordination Disorder (DCD). The DSM IV criteria for this diagnosis are as follows:

A. Performance in daily activities that require motor co-ordination is substantially below that expected given the person’s chronological age and measured intelligence. This may be manifested by marked delays in achieving motor milestones, dropping things, “clumsiness”, poor performance in sports, or poor handwriting.

B. The disturbance in criterion A significantly interferes with academic achievement or activities in daily living.
C. The disturbance is not due to a medical condition, and does not meet criteria for a pervasive developmental disorder.
D. If mental retardation is present, the motor difficulties are in excess of those usually associated with it.

In clinical settings difficulties may be encountered in deciding upon the DCD diagnosis, as children are constantly in a developmental process and the relevant classification systems are not precise (1, 7, 8, 49). According to DSM IV, there are four groups of motor impairments that have to be distinguished from DCD, namely specific neurological disorders, mental retardation, pervasive developmental disorder (e.g. autistic disorder and Asperger’s disorder), and attention deficit/ hyperactivity disorder (ADHD). The diagnosis DCD is not applicable when criteria for a specific neurological disorder or pervasive developmental disorder are met. It can be given when criteria for mental retardation are fulfilled. When criteria for both DCD and ADHD are met, both diagnoses should be given (1).

Approximately 5 to 6 per cent of all children are given the diagnosis DCD when they are 7 years old (1), and the reported male:female ratio of DCD in a population of 7-year-olds varies between 3:1 and 7:1 (52). Besides DCD, the term Deficits in Attention, Motor Control and Perception (DAMP) is used in Scandinavian countries (22). According to Gillberg et al. (21), this term encompasses both children with DCD and children with ADHD (DSM IV). Follow-up studies of children who before school entrance have been diagnosed as having delayed motor development have shown that motor difficulties persist in approximately 50 per cent of the children. (11, 19, 37, 38, 52, 61). Cantell et al. (11) suggest that the social and educational outcomes may be poorest in the children with the most extreme motor difficulties at age 5, or in those with motor difficulties associated with lower intellectual abilities.

Consensus on DCD
In 1994 an international consensus meeting concerning DCD was held in Canada (68). A statement on the nomenclature, description and definition, assessment and management was agreed to by an international multi-disciplinary group of experts, and comments were made on the essential database for scientific communications. DCD was defined as a chronic and usually permanent condition, manifested as movement problems. There is a high incidence of associated problems in a wide range of functions (68). Since 1994 there have been regular multi-disciplinary conferences of scientists and clinicians who share an interest in DCD (4, 39). There are still some problems to be solved concerning classification of motor co-ordination disorders in children. It is unclear what tests should be used, what items the tests should contain to evaluate fine and gross motor co-ordination, and what degree of impairment in
performance is required to set the diagnosis. Henderson and Barnett (40) also point out the problems in deciding what signs of neurological disorder should exclude such a diagnosis and how such signs should be identified, and how motor ability should be considered in relation to intellectual ability.

**Associated problems in DCD**

Self-perceived competence and social acceptance are secondary characteristics to be considered. Perceived competence is the self-estimation of how well one can execute the actions that are necessary in daily life and varies depending on the activity in question (2). School children with motor difficulties describe themselves as less competent in physical skills (55, 63, 79). When adolescents, they may also report themselves to be less scholastic and socially competent than controls (11, 61). The perception of competence may influence the question whether children want to be involved in physical activities or not, and whether they want to persist with the activities in which they have started to participate. The involvement cycle will most likely be a negative spiral for the unconfident individual (27). It is suggested that a child’s actual motor competence has less impact upon his motivation than his self-perceived motor competence (27, 33). In addition, children with motor difficulties may have emotional, behavioural and academic problems. Parents are usually reliable observers of their children’s performance in daily activities (18, 68). In a developmental screening programme, the parents are usually asked for information in a standardised inventory (50). However, professionals also spend a considerable amount of time in informal discussions with parents who may have been concerned about late motor milestones in their children before school entrance. The parents may have sought medical advice, but the problem may not always have been formally recognised (23, 24, 25, 61).

**Motor skill intervention**

The intervention in these children should be holistic and multi-faceted and designed to meet the needs of each individual child. It may incorporate appropriate motor training techniques, the teaching of coping strategies, consultation with teachers and parents, and modification of the school environment (68). Steyer David (88) believes that an important part of an assessment for DCD is the follow-up consultation at which the dysfunction is explained to the child, the parents and the school personnel. The physiotherapist may be the first to identify DCD and is in this case responsible for making appropriate referrals to other professionals (57, 87, 88). The primary concern of a therapist is how best to facilitate learning and motor skill acquisition (59, 94). Van Rossum and Vermeer (93) suggest that motor training in children with motor difficulties should aim not only at improving the level of motor
competence, but also at forming a realistic relationship between motor competence and perceived competence.

Effects of different types of motor skill intervention have been reported in reviews (30, 44, 66, 67, 75, 81). However, few reviews (65, 80, 82) have dealt with the effects of different kinds of such intervention on motor difficulties consistent with DCD. Motor training methods may be based on different theoretical perspectives and have different modes of administration. The basis of the *General Abilities approach* is that age-appropriate reflexes, postural reactions and perceptual-motor abilities all underlie functional motor skills and conceptual development. The intervention with this approach consists mainly of facilitation of balance and other physical abilities and training in specific perceptual and motor tasks. With the *Sensory Integration approach* it is assumed that the development of cognition, language, and academic and motor skills depends on the sensory integrative ability. Children with sensory-motor problems are given proprioceptive, tactile and vestibular stimulation to improve the brain process and their motor skills. The *Specific Skills approach* is based on the assumption that specific motor control and motor learning processes underlie skilled movement, and that the key to successful motor training is that an active child should practise functional skills with appropriate repetition and guidance.

The training of children with DCD may be time-consuming in that it is mostly individualised. At present there are few organised structures in society to deal with the motor difficulties in these children (58). It is important to find beneficial motor skill intervention that is easily available to children and their families, and that promotes the children’s development together with peers. In the municipalities there are gymnastic and sport associations that organise physical group activities for children. In some cities these associations also organise small groups for children with motor difficulties. A physiotherapist may assist in the development of motor curricula for community recreation, and make appropriate recommendations for children whom she/he refers to other professionals (88). Positive effects of adapted physical education have been reported (71, 72), but on the whole few studies have addressed the effects of group motor training in children with motor difficulties consistent with DCD.

**Aims**

In Sweden a majority of all 5- to 6-year-old children are offered participation in a developmental screening programme (85), which is carried out in the CHC. The aims of the present work were to investigate whether there is evidence to support motor skill intervention in children with motor difficulties consistent with DCD diagnosed at a CHC before school entrance, to analyse their parents’ descriptions, and to elucidate changes in the children’s motor status by a short-term follow-up. Specific questions addressed were as follows:
• What evidence has been produced in previous research to support motor skill intervention in children with DCD? (Study I)
• Does group motor skill intervention have an effect on motor skill (Study I) or on self-perceived competence (Study II) in 5-to 6-year-old children with DCD?
• Does self-perceived competence differ between children with DCD and children in a reference group? (Study III)
• How do the parents describe their 5- to 6-year-old children with DCD? (Study IV)
• What is the motor status of the children with DCD when re-examined at age 7 to 8, and how does it compare with their motor status at 5 to 6 years of age? (Study V)
MATERIAL AND METHODS

Study I was based on previous research concerning the effects of motor skill intervention. Studies II and III comprised children of 5 to 6 years who were diagnosed as having motor difficulties consistent with DCD, and in Study V these 5- to 6-year-old children were followed up at the age of 7-8. Study IV concerned their parents’ descriptions. An overview of the bases of each study is presented in Figure 1.

<table>
<thead>
<tr>
<th>Reviewed studies N = 13/21</th>
<th>Children with DCD N = 37</th>
<th>Reference group N = 60</th>
<th>Parents N = 37</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study I</td>
<td>Study II</td>
<td>Study III</td>
<td>Study IV</td>
</tr>
<tr>
<td></td>
<td>Study V</td>
<td></td>
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</tbody>
</table>

Fig. 1. Overview of the bases of the studies

Study I was a meta-analysis of the results of studies undertaken to examine the effects of motor skill intervention in children with DCD. Criteria for inclusion of studies were: (a) the study population comprised children identified as having motor difficulties consistent with DCD, (b) either an experimental design with at least one control group or a single subject design, (c) effects of motor skill intervention were reported, and (d) means and standard deviations were reported for experimental and control groups. Twenty-one studies fulfilled the first three criteria. Means and standard deviations for groups were reported for only 13 of the 21 studies.

For the meta-analysis a coding scheme for variables in each of the 13 studies was formulated. The theoretical approach of the motor skill intervention was coded as the General Abilities approach, the Sensory Integration approach, the Specific Skill approach, or a combination of these three. Age in years was coded as 3 to 5 or 6 to 13 years, and gender was coded as male or female. Research design was coded according to how the assignment of participants to groups had
been performed, and as (a) a between-subjects design with a pre- and post-test, (b) a between-subjects design without a pre- and post-test, or (c) a within-subject design. Intervention setting was coded as small group (intervention performed by a teacher), home programme (performed by parents), or one-to-one setting (performed by a physiotherapist or an occupational therapist). Intervention duration was coded as less than 3 months, or 3 months or more, and frequency was coded as less than 3 times/week or 3 to 5 times/week.

**Study II and Study III,** which comprised children of ages 5 to 6 years with motor difficulties consistent with the diagnosis DCD, addressed the effects of group motor skill intervention measured as change in motor skill (Study II) and self-perceived competence (Study III). The inclusion criteria were: (1) the child had failed in the CHC motor screening test (20), (2) when necessary both a doctor and a psychologist had ruled out a neurological or behavioural disorder, (3) parents had agreed to participation, and (4) the child’s total score at a Movement ABC motor test (42) indicated borderline or definite motor difficulties. The children (N = 37) included were randomly allocated to an experimental (n = 17) and a control (n = 20) group. The children in the two groups did not differ significantly concerning age, gender, or visual, speech or hearing problems, or in the severity of their motor difficulties. The parents in the two groups did not differ with regard to education and profession. In study II both the Movement ABC motor test and the Movement ABC checklist were used to evaluate the effects of group motor skill intervention on motor skills. In study III the Perceived Motor Competence scale and the UMESOL Balloon- and Flag-child scale (89) were used to evaluate the effects of group motor skill intervention on self-perceived competence.

In **Study III** the 5- to 6-year-old children were also compared with a reference group of children of the same age (N = 60) regarding two scales of self-perceived competence. All children in the reference group were attending day-care centres, their parents had agreed to their participation, and their teachers had ascertained that they were able to speak and understand Swedish. The reference group comprised 31 boys and 29 girls who were selected from four day-care centres in a city in central Sweden.

**Study IV** was a qualitative study of descriptions given by parents of 5- to 6-year-old children with motor difficulties consistent with DCD. Thirty-seven parents were interviewed. The parents were included when their children had failed both the CHC motor screening test for 5- to 6-year-olds in Uppsala and the Movement ABC motor test. To investigate the parents’ descriptions of what they had observed, felt and done concerning their children, a semi-structured interview guide was used. At the beginning of all interviews the questions were also explained in an example. The first author interviewed the parents before
examining the children with the Movement ABC motor test. The children were present during the interviews, each of which lasted for up to 12 minutes. All interviews were tape-recorded.

**Study V** was a follow-up study conducted one and a half years later. The aim was to re-examine children who after the motor screening at CHC had been diagnosed as having motor difficulties consistent with DCD, in order to determine their motor status when they were 7 to 8 years old and to compare it with that at age 5-6. The criteria for inclusion of children were the same as in Studies II and III. The Movement ABC motor test and the Perceived Motor Competence scale were used, and the parents’ descriptions of the motor status and motor development in their children were analysed.

**Motor skill intervention**
The group motor skill intervention received by the children in the experimental group (Studies II and III) was of a type administered by a gymnastic organisation available to any 5- to 6-year-old child in the municipality of Uppsala. A physical educator conducted the intervention once a week for 10 weeks. The parents assisted verbally and by hands-on when needed. Usually 6 to 8 children (maximum 10) with motor difficulties constituted one group. The adopted intervention had an eclectic theoretical approach and was based on practice of functional skills, with an opportunity to practise the skill until the child succeeded and was able to manage it in different situations. The children practised balance, ball-playing and gross motor skills. They were supervised and guided by a physical educator who was not familiar with methods used by physiotherapists. However, the physiotherapist informed the physical educator about the children’s main motor difficulties. Purposeful and enjoyable motor play activities were planned such as to enhance the children’s willingness to practise, and the activities included much repetition. The equipment consisted of wall bars, horizontal bars, a box horse, carpets, flying rings, and a music tape-recorder. Each child brought his or her own skipping rope and ball. The children practised with gymnastic apparatus in an obstacle course. At the end of a session they played a game together.

The evaluation and consultative services, which children in both the experimental and control group received (Studies II and III), consisted of two meetings with each child, lasting a total of three hours. The purpose was to help the parents to understand their child’s motor difficulties by giving them an opportunity to observe the child under the guidance of a physiotherapist in primary health care. A written document of the assessment was given to the parents. Between the two meetings, the child was usually asked to practise a motor task at home.
Measures

The Effect Size (ES) measure is the degree to which a phenomenon is present in the population, or the degree to which the null hypothesis is false. It is an approximation procedure to estimate the power of a test. The sample means and variances yield a rough estimation of ES, and a personal assessment is made of which difference between samples is important. Finally, ES is combined with the sample size. In a meta-analysis, ES are (a) calculated for the outcomes of studies or sometimes for comparisons within studies, (b) averaged across studies to estimate the general magnitude of an effect, or (c) compared between studies to determine whether there is any variation in study outcome, and if so, to find out what features of the studies might account for them (Study I).

The Movement ABC motor test is a norm-referenced screening test for children 4 to 12 years old, which has also been used as an evaluative test (Studies II and V). There are eight items in the areas of manual dexterity, ball skills, and static and dynamic balance. Each item is scored 0 to 5. The maximum total score is 40, with the higher scores indicating lower motor competence. The test has age-related norms and two cut-off points. Total impairment scores at the 5th percentile or more should be considered as indicating definite motor difficulties. Scores between the 5th and 15th percentiles indicate borderline motor difficulties.

The motor sections on the Movement ABC checklist are used to assess naturally occurring motor interactions between children 5 to 11 years old and their physical environment. A person familiar with the child carries out the observation daily for 2 to 3 weeks. The Movement ABC checklist has four motor sections, with 12 items in each with tasks of increasing complexity. There are four alternative scores, which indicate how well the child deals with each task. A higher total score indicates lower motor competence (Study II).

The UMESOL Balloon- and Flag-child scale consists of 20 paired statements concerning school and peer relations. Each paired statement is scored 0 or 1. A high total score on a scale indicates high perceived competence. Each statement is opposed, e.g. “other children want to play with me” or “other children do not want to play with me.” Accompanying these statements are drawings of two children called the balloon-child and the flag-child. The examiner reads out the two statements and asks the child “Which child is most like you?” The child responds by putting a pencil mark on the figure that most accurately reflects his perceived competence (Study III).

The Perceived Motor Competence scale consists of 19 statements with a gross and a fine motor sub-scale. Each paired statement is scored 0 or 1. A high total score on a scale indicates high perceived competence. Each statement is
opposed, e.g. “good at riding a bicycle” or “not good at riding a bicycle”. Accompanying these paired statements are drawings of two children called the dot-child and the square-child. The same drawings are used with all statements in this test. The examiner reads out the two statements and then asks the child “Which child is most like you?” The child puts a sign on the figure that most accurately reflects his perceived physical competence (Studies III and V).

The observation scheme for confirming participation in group motor skill intervention concerned the extent to which the children in the experimental group participated in each of the seven parts constituting a group motor skill training session. The physical educator completed the protocol for observation on each child immediately after each session. A four-point scale was used to evaluate the children’s participation (Studies II and III).

The parent questionnaire concerned the question whether physical and social factors other than the group motor skill intervention evaluated could have affected the children’s motor performance. There were six questions: start of new physical activity at home/ in spare time/ at the day-care centre, infection or illness, a traumatic event in the family, and the parents’ own opinions as to what might have affected the children’s motor competence. At a post-intervention test the parents brought the questionnaire, which they had completed at home (Studies II and III).

The parent interview consisted of three questions about observations, feelings and actions: What have you observed concerning your child’s motor ability and development? What do you feel about the observation in your child that you have just mentioned? What have you done about the observation in your child that you have just mentioned? At the beginning of the interview the parents were told about all three questions, and these were also explained in an example. All three questions required follow-up questions (Studies IV and V).

Data analysis
Effect size was investigated by calculating the difference between the means of the two groups compared in each study and dividing this by the standard deviations pooled \((ES = M_{exp} – M_{con} / SD_p)\). When only one group was studied, the means obtained at pre- and post intervention tests were used \((ES = M_{post} – M_{pre} / SD_{pre})\). The mean effect size (MES) was calculated as the mean of all ES values of dependent measures in an experiment. Finally, all MES of an experiment were used to calculate the mean main ES among various coding characteristics (Study I).

The independent sample t-test, repeated measure ANOVA, and the Mann-Whitney U test, Chi-square test and Friedman test were all used to analyse
differences between groups or variables (Studies II, III, V). Repeated measure ANOVA, the Wilcoxon Signed-Rank test and the Kruskal Wallis test were used to analyse differences within groups (Studies II and V).

The interviews were transcribed verbatim and coded. The analysis of the interview material in study IV started with coding of all interviews, which sorted out common categories in the background data. Categories were clustered into themes, and definitions were created. Credibility in categories and themes was ensured by analysis of negative cases and alternative explanations. Two of the authors read the results of all 37 interviews and performed coding of their own. The inter-rater reliability of the categories and themes was tested.

An overview of the design, instruments, tests, and methods for data analysis applied in each of the studies I to V is presented in Table I.

Table I. Overview of the design, instruments/ tests and data analysis in each study

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Instruments/ tests</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Descriptive and comparative</td>
<td>Educational Resources Information Center (ERIC) Cinahl Medline PsychInfo SPORT Discus (SIRC/CDS) Effect Size</td>
<td>Meta-analysis: Standard deviation pooled (SDp) ES = Mexp – Mcon / SDp ES = Mpost – Mpre / Sdpre MES = mean of all ES</td>
</tr>
<tr>
<td>II</td>
<td>Experimental</td>
<td>Motor screening test Movement ABC motor test Movement ABC checklist Parent Questionnaire Observation of participation in training</td>
<td>t-test Repeated measure ANOVA Mann-Whitney U test Friedman test Chi-square test Wilcoxon Signed-Rank test Kruskal Wallis test</td>
</tr>
<tr>
<td>III</td>
<td>Experimental and comparative</td>
<td>Motor Screening test Movement ABC motor test UMESOL Balloon- and Flag-child scale Perceived Motor Competence scale Parent Questionnaire Observation scheme for participation in intervention</td>
<td>t-test Mann-Whitney U test Chi-square test</td>
</tr>
<tr>
<td>IV</td>
<td>Descriptive and comparative</td>
<td>Motor screening test Movement ABC motor test Parent interview guide</td>
<td>Coding of interviews into categories and themes Analysis of negative cases and alternative explanations Inter-rater reliability of categories and themes</td>
</tr>
<tr>
<td>V</td>
<td>Descriptive and comparative</td>
<td>Motor screening test Movement ABC motor test Perceived Motor Competence scale Parent interview guide</td>
<td>t-test Mann-Whitney U test Wilcoxon Signed-Rank test</td>
</tr>
</tbody>
</table>
Ethics
The studies were approved by the Ethics Committee of the Faculty of Medicine at the University of Uppsala (No 219/95). Informed consent was obtained from parents and children prior to all investigations.
RESULTS

Evidence found in previous research to support motor skill intervention in children with DCD (Study I)

Studies in which motor skill intervention was based on the Specific Skills theoretical approach yielded the highest mean main effect size. Studies in children 6 - 13 years old gave a mean main ES of 0.77. In research where children were randomly assigned to groups, the mean main ES was lower than when children were matched and randomly assigned, but all types of assignment of participants seemed to support intervention. Administration of intervention in a one-to-one setting was most frequently used. This setting gave the lowest mean main ES, compared to administration in a small group or in a home programme. Concerning length of intervention, the mean main ES was similar irrespective of whether the intervention lasted less than 3 months, or 3 months or more. A frequency of intervention coded as 3 to 5 times per week yielded a higher mean main ES than less frequent intervention. The mean main ES for each coding characteristic in the meta-analysis are presented in Table II.

Table II. Mean main effect size (ES) for each coding characteristic calculated from the mean ES in each experiment (n = 18). MES = mean effect size.

<table>
<thead>
<tr>
<th>Coding characteristics</th>
<th>n</th>
<th>Mean main ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GA = General Abilities</td>
<td>9</td>
<td>0.71</td>
</tr>
<tr>
<td>SI = Sensory Integration</td>
<td>4</td>
<td>0.21</td>
</tr>
<tr>
<td>SS = Specific Skills</td>
<td>3</td>
<td>1.46</td>
</tr>
<tr>
<td>GA + SS</td>
<td>1</td>
<td>0.20</td>
</tr>
<tr>
<td>GA + SI</td>
<td>1</td>
<td>0.07</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 to 5 years</td>
<td>2</td>
<td>0.14</td>
</tr>
<tr>
<td>6 to 13 years</td>
<td>16</td>
<td>0.77</td>
</tr>
<tr>
<td>Research design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Randomly assigned</td>
<td>13</td>
<td>0.56</td>
</tr>
<tr>
<td>Matched and randomly assigned</td>
<td>2</td>
<td>1.15</td>
</tr>
<tr>
<td>Matched, but not randomly assigned</td>
<td>3</td>
<td>0.99</td>
</tr>
<tr>
<td>Single-subject design</td>
<td>-</td>
<td>No data for ES calculation</td>
</tr>
<tr>
<td>Intervention setting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small group</td>
<td>5</td>
<td>0.96</td>
</tr>
<tr>
<td>Home programme</td>
<td>2</td>
<td>1.41</td>
</tr>
<tr>
<td>One-to-one setting</td>
<td>11</td>
<td>0.45</td>
</tr>
<tr>
<td>Intervention duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 3 months</td>
<td>8</td>
<td>0.72</td>
</tr>
<tr>
<td>3 months or more</td>
<td>10</td>
<td>0.69</td>
</tr>
<tr>
<td>Intervention frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 3 / week</td>
<td>11</td>
<td>0.60</td>
</tr>
<tr>
<td>3 - 5 / week</td>
<td>7</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Note. See Paper I, Table 3.
Effects of group motor skill intervention on motor skill (Study II) and self-perceived competence (Study III) in 5- to 6-year-old children with DCD

The primary aim of study II was to determine whether, after group motor skill intervention in the experimental group, the experimental (n = 17) and control (n = 20) groups differed regarding the total score in the Movement ABC motor test. No significant difference was found in this respect in either the within-subjects or between-subjects analysis. A second aim was to find out whether after the intervention the experimental and control groups differed with respect to the total score in the Movement ABC checklist. There was no significant difference in the within-subjects or between-subjects analysis.

A third aim was to determine whether the experimental and control groups differed when they were divided into sub-groups of children with definite and borderline motor difficulties. In the Movement ABC motor test the difference in total score in the within-subjects analysis was not significant. In the Movement ABC checklist no significant difference was found either in the within-subjects or between-subjects analysis. After the intervention, the experimental and control sub-groups were compared regarding the number of children who had changed their category regarding severity of motor difficulties (Table III). The categorisation of this severity stemmed from the Movement ABC motor test and was based on scores in a norm group. There was a significant difference between the definite and between the borderline sub-groups regarding the number of children who had changed their category. Seven of the eight children with borderline motor difficulties in the experimental group had changed category and no longer had motor difficulties. In the control group five of the ten children with borderline motor difficulties had changed to the category with definite motor difficulties.

Table III. The number of 5- to 6-year-old children in the experimental and control sub-groups and their change in category regarding severity of motor difficulties at the post-intervention test

<table>
<thead>
<tr>
<th></th>
<th>Pre-intervention category of motor difficulty</th>
<th>Post-intervention category of motor difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definite</td>
<td>Borderline</td>
</tr>
<tr>
<td>Experimental group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definite, n = 9</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Borderline, n = 8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Control group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definite, n = 10</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Borderline, n = 10</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Note 1. Wilcoxon Signed-Rank test, \( p = .033 \)

Note 2. See Paper II, Table 3.
No significant differences were found between the experimental (n = 17) and control (n = 20) groups either at the pre- or at the post-intervention test regarding the total score in the UMESOL Balloon- and Flag-child scale and the Perceived Motor Competence scale. This was true both when the comparisons were made between the whole groups and when the children with borderline or definite motor difficulties were compared. A change in score at the post-intervention test was recorded as a change irrespective of whether it was positive or negative. The median change in score in the Perceived Motor Competence scale in the experimental group was 3 (range = 5), while that in the control group was 1 (range = 6). There was a significant difference (\( p = 0.012 \)) in change in score in the Perceived Motor Competence scale in children with definite motor difficulties in the experimental group, and hence in the whole experimental group, compared with the control group.

Self-perceived competence in children with DCD compared with children in a reference group (Study III)

There were no significant differences between the study group of children with DCD (N = 37) and the reference group (N = 60) in the two scales of self-perceived competence. Also when the study group was divided into a sub-group with borderline motor difficulties (n = 18) and one with definite motor difficulties (n = 19) the median total score in the UMESOL Balloon- and Flag-child scale was the same (Md = 16) in all three groups. In the Perceived Motor Competence scale the median total score was 17.5 in the sub-group with borderline motor difficulties, and 16 in the other two groups.

Parent’s descriptions concerning DCD in their 5- to 6-year-old children (Study IV)

Parents were asked to describe their observations, feelings and actions regarding their children. A total of 5 themes and 16 defined categories emerged from the interviews. The themes and all categories are presented in Table IV.

Theme I. Motor behaviours in specific situations. The parents’ observations in different settings and situations mainly concerned the question of whether a motor behaviour was present or not; for example can or cannot ride a bicycle. The parents also made evaluations of how well their children were able to perform a motor activity in a specific situation. Probe questions were needed to obtain a full description of behaviours not indicating late development or motor deficits.

Theme II. Overall impression of behaviours. The parents were not asked directly in the interview guide to give their overall impression of their children’s
behaviours. The parents summarised their described impressions when they had reflected on what they had said.

**Theme III. Communicative and physical observations.** Observations in areas other than motor behaviours were also reported. During the interview some of the parents reported and discussed these observations in connection with, or as a possible cause of, their children’s motor behaviour problems.

**Theme IV. Emotions concerning parenthood.** Question two in the interview guide addressed the parents’ feelings regarding their observations. All parents answered the question by describing their emotions in connection with situations and thoughts. Parents whose children had definite motor difficulties made strong and repeated statements in the category “Worry and uncertainty”.

**Theme V. Support in physical activity.** During the interview the parents continuously mentioned their support of their children in physical activities. Some of them also stated that they did not know what to do. Some parents whose children had borderline motor difficulties reported that they gave no special support or were thinking about it, while parents whose children had definite motor difficulties claimed that they gave their support in naturally occurring situations and encouraged training.

### Table IV. Themes and categories emerging from the interviews

<table>
<thead>
<tr>
<th>Themes I – V</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Motor behaviours in specific situations</td>
<td>Play, sport and locomotion</td>
</tr>
<tr>
<td></td>
<td>Test situation</td>
</tr>
<tr>
<td></td>
<td>Meals and dressing</td>
</tr>
<tr>
<td>II. Overall impression of behaviours</td>
<td>Clumsiness, tension and mobility</td>
</tr>
<tr>
<td></td>
<td>Activity level</td>
</tr>
<tr>
<td></td>
<td>Development, maturation and comparison</td>
</tr>
<tr>
<td></td>
<td>Reflections</td>
</tr>
<tr>
<td>III. Communicative and physical observations</td>
<td>Speech and understanding</td>
</tr>
<tr>
<td></td>
<td>Vision and hearing</td>
</tr>
<tr>
<td></td>
<td>Weight and height</td>
</tr>
<tr>
<td>IV. Emotions concerning parenthood</td>
<td>Worry and uncertainty</td>
</tr>
<tr>
<td></td>
<td>Anger and irritation</td>
</tr>
<tr>
<td></td>
<td>Surprise</td>
</tr>
<tr>
<td>V. Support in physical activity</td>
<td>No support or thinking about it</td>
</tr>
<tr>
<td></td>
<td>Support in naturally occurring situations</td>
</tr>
<tr>
<td></td>
<td>Support by encouraged training</td>
</tr>
</tbody>
</table>
Motor status of the children with DCD when re-examined at age 7 to 8 years (Study V)

The children’s mean total score in the Movement ABC motor test was 15.3 (SD = 7.77), and according to this test they had either definite motor difficulties (n = 20), borderline motor difficulties (n = 9) or no motor difficulties (n = 8). In the Perceived Motor Competence scale, groups of children with definite, borderline, or no motor difficulties had significantly different scores (p = 0.022). Children with definite motor difficulties had a lower median score of 15.

Table V shows the numbers of children with definite and borderline motor difficulties at age 5 to 6 years, and the numbers who had changed to different categories at age 7 to 8. The children are presented as groups a to f. Twenty-two children had not changed category (groups a and e), while 10 had improved (groups b, c and f) and 5 had deteriorated (group d). Most children with definite motor difficulties at age 5 to 6 remained in the same category at age 7 to 8, while the majority of children who had borderline motor difficulties had changed into having either definite or no motor difficulties. No significant difference was found when the study group’s total score in the PMC scale or the Movement ABC motor test at age 7 to 8 were compared with the respective test at age 5 to 6.

Table V. Changes in the degree of severity of motor difficulties between the ages of 5 to 6 and 7 to 8 years, according to the Movement ABC motor test. Groups a and e represent no change in category, b, c and f improvement, and d deterioration. Numbers (n) of children.

<table>
<thead>
<tr>
<th>Degree of severity of motor difficulties at age 5 to 6</th>
<th>Degree of severity of motor difficulties at age 7 to 8</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definite n = 20</td>
<td>Borderline n = 8</td>
<td>None n = 9</td>
<td></td>
</tr>
<tr>
<td>Definite n = 19</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>a b c</td>
</tr>
<tr>
<td>Borderline n = 18</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>d e f</td>
</tr>
</tbody>
</table>

Note 1. Wilcoxon Signed-Rank test, NS.
Note 2. See Paper V, Table 1
The parents whose children had no motor difficulties at age 7 to 8 described their children as being physically active at home together with friends, or participating in several sports. These parents also reported improvement in their children’s motor competence compared with that at age 5-6. The parents whose children had borderline motor difficulties stated that the clumsiness in their children was still evident, but that they had improved and were physically active. The parents whose children had definite motor difficulties reported, in their children, a lack of improvement in motor skills, lack of motivation and unwillingness to participate in physical activities, and described their own anxiety.

In Table VI boys and girls of the study group are compared regarding their change to different categories of motor difficulties between the ages of 5 - 6 and 7 - 8 years. At the age of 7 - 8 a higher percentage of girls showed deterioration and a higher percentage of boys showed improvement.

Table VI. Numbers of boys and girls in the study group and their changes to different categories of motor difficulties between the ages of 5 to 6 and 7 to 8, according to the Movement ABC motor test.

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deterioration</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>(7%)</td>
<td>(27%)</td>
<td></td>
</tr>
<tr>
<td>No change</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>(62%)</td>
<td>(55%)</td>
<td></td>
</tr>
<tr>
<td>Improvement</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>(31%)</td>
<td>(18%)</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

Main results
In the review in study I evidence was found in previous research to support motor skill intervention in children with DCD who are older than 5 years of age. Especially beneficial was intervention using the Specific Skills and the General Abilities theoretical approaches, intervention conducted in a group setting or in a home programme, and intervention with a frequency of at least 3 to 5 times per week. In studies II and III the group motor skill intervention resulted in a change in some children from having borderline motor difficulties to having no motor difficulties, according to the motor test used. Furthermore, the motor skill intervention seemed to affect the awareness of motor competence, seen as a change in score in a self-perceived motor competence scale, either positive or negative.

In study IV the parents described the motor competence and limitations of their 5- to 6-year-old children with DCD, both in specific situations and as an overall impression. They also described their reflections on communicative and physical observations, emotions concerning parenthood, and their support of the child’s physical activity. Parents whose children had definite motor difficulties were more inclined to support their children both in naturally occurring situations and by encouraging training. These parents also made strong and repeated statements about the worry and uncertainty they experienced in parenthood.

On a group level, children who had been diagnosed as having motor difficulties consistent with DCD when 5 to 6 years old had not changed their motor status at age 7 to 8, according to a motor test and a self-perceived motor competence scale. On an individual level, the majority of children with borderline motor difficulties had changed to having either definite or no motor difficulties at the re-examination. According to their parents, the children who had changed to having no motor difficulties were physically active in sports, at home and with peers.

Methodological comments
All studies reviewed in the meta-analysis (Study I) included children with motor difficulties consistent with DCD, but only those studies in which outcome results were analysed on differences in mean values and standard deviations were considered. This is the most widely used method for analysing effect size (5, 13, 16, 45, 90, 91), but there are other ways (36, 74). In five studies (44, 48, 51, 60, 83) of the eight not included in the meta-analysis, the p values, but not means and standard deviation, were reported. In three of these studies intervention was evaluated with the Sensory Integration theoretical approach
and in two of these three some significant effects were reported. In the other two of the five studies effects of combined interventions were investigated. In these studies also, some significant effects were reported.

In DSM IV (1) it is stated that for a diagnosis of DCD in children the motor co-ordination should be substantially below that expected given the child’s chronological age. The two-step selection procedure ensured that according to the Movement ABC motor test, the children included could not perform motor tasks that can be managed by 85 per cent of age-related peers. Whether the 15th percentile in the motor test was the appropriate level for separating motor performance into substantially below normal and not substantially below normal may be discussed. Henderson and Barnett (40) state that within the medical profession children falling below the 10th percentile are usually designated as “impaired”, while psychologists and educators use the 15th percentile. Furthermore, the children’s disturbance was not due to a medical disorder, and an inquiry made to the parents four years after inclusion ensured that the children were not attending classes for children with mental retardation. In DSM IV it is also stated as a criterion that the children’s motor difficulties should significantly interfere with academic skills. However, in pre-school children it is difficult to judge whether their motor difficulties are significantly interfering with academic skills. Henderson and Barnett (40) point out that the academic achievement criterion in the early childhood years may detract attention from the importance of motor competence in itself. They also argue that the reference to academic achievement fails to take into account the pre-school child who may not be able to play with peers and is hence unable to socially adjust (17).

There is a possibility that the 37 parents included in studies IV and V were especially observant of the motor competence of their children, or were more worried, or more supportive in physical activities compared with the parents who declined participation (N = 47) when the children were 5 to 6 years old (Study II). The factors mentioned might be connected with the parents’ socio-economic status. An investigation to find out in which socio-economic housing areas the parents lived revealed that all areas that were represented by the group of parents who were included in the studies were also found among the parents who declined participation. Only in one housing area were the parents who declined participation over-represented. This area is a suburb of the city of Uppsala, and most people who live there work in the city. Several of these parents stated that they declined participation because they would not be able to get to the intervention sessions in time.

In previous studies (63, 64, 79) well-known scales of self-perceived competence have been used for investigation in school children with motor difficulties (34, 64). Both scales used in the present study had been applied in school children,
while only the Balloon- and Flag-child scale had been used in Swedish school children (89). Nevertheless, neither of the two scales had been used in children as young as 5 to 6 years. Children of this young age may not yet have experienced all tasks in the scales used in school children and also they may not yet have started to compare their competence with others (95). The total scores in the group of children with motor difficulties were therefore compared with scores in a reference group of age-related peers not diagnosed as having motor difficulties. All children were able to answer and interested in answering the questions, and no difference was found between the two groups.

**Effects of motor skill intervention**

The desired effects of motor skill intervention may be expressed in different ways, but the principal aim is to improve motor skill and to promote a healthy life-style (35). To achieve these effects the children have to participate in physical activities. Some need more training to improve their motor skills, while others need less. Perception of motor competence is mentioned as another factor that may be affected by physical activity. The children who need less training to achieve a skill may soon perceive their motor competence as high, and they may feel motivated to participate in physical activities. However, for children who are physically less competent there is a risk that the participation may result in a vicious circle. The children with low motor competence may as time passes choose not to participate in any physical activity at all.

The most effective motor skill intervention in study I was based on the Specific Skills theoretical approach and had a frequency of 3 to 5 times per week, and took place in a group setting or as a home programme. Study II was designed before the results of study I had become available. Nevertheless, study II showed that in children with borderline motor difficulties, group motor skill intervention using a non-specific skill approach and conducted once a week also had effects, in that more of these children changed their category of motor difficulties to having no such difficulties. This latter finding was in accordance with results of other studies (71, 72), in which positive effects of motor skill intervention were obtained using programmes with adapted physical education administered in a group once weekly. In the children with definite motor difficulties, no effects of motor skill intervention on motor skills were observed in study II. Thus studies I and II contributed to the knowledge of how motor skill intervention can be performed in children with borderline motor difficulties, and of the benefits in this group of children. However, of the three recommended ways of conducting motor skill intervention that were effective in study I, only group administration was tested in study II. Left to investigate is an intervention with the Specific Skills theoretical approach consisting of individualised specific motor skills and administered more frequently. The children with definite motor difficulties may benefit from a combination of these
three recommendations. In study I the least effective administration was in a one-to-one-setting. It is likely that especially the children who had severe or definite motor difficulties in the reviewed studies received intervention administered in this way. Larkin and Hoare (58) have stated that in all children with motor difficulties it is effective from a teaching and socialising perspective to work in small groups. In groups, the children are encouraged to co-operate so that they can attend to their own progress rather than competitively comparing their own performance with that of others. Concerning the possibilities of meeting the individual’s needs in a group, Revie and Larkin (71) showed that sessions with training of specific tasks can be incorporated within a programme called “Uniplay”. In each group session the children were taught two specific tasks and the remainder of the teaching time was spent according to the children’s needs. To increase the intensity of motor skill intervention in children with definite motor difficulties, the effects of the task-specific motor skill group intervention may be combined with those of a home programme. There is now an urgent need for well-designed studies to evaluate well-designed interventions in children with definite or severe motor difficulties consistent with DCD (43, 53).

Effects of motor skill intervention on self-perceived competence have previously been investigated in school children with motor difficulties (28, 47, 69, 92, 93), but not in pre-school children. In study III the self-perceived motor competence was the only area of perceived competence on which group motor skill intervention had an effect, and the effect observed was a positive or negative change. Results from other studies (28, 55, 63, 76, 79) have shown that school children with motor difficulties report perceptions of their physical competence that accurately reflect this competence. Van Rossum (93) proposed that with respect to the relationship between perceived competence and actual competence, motor skill training should aim not only at improving motor performance, but more importantly at forming a realistic relationship between motor competence and perceived motor competence. The child may then decide whether to train or not, and what to improve. It may be assumed that when a child has achieved realistic self-perceived motor competence, an increase in actual motor competence is likely to result in an increase in self-perceived motor competence. Nevertheless, in some children the motor difficulties persist.

**Parental roles as parent and co-therapist**

In study IV parents described their children's motor skills in specific situations and their overall impression of their children's behaviours. The descriptions concerned motor skills and behaviours encountered in everyday situations. This is in accordance with the remark by Rodger (73) that parents have the greatest degree of contact with their children in natural environments. The results of study IV also show that parents compare their children's development with that of other children. Although parents compare, Stephenson et al. (87) concluded
that some parents whose children have motor difficulties believe in the existence of a problem before professionals do, while others do not. Professionals may explicitly ask parents what comparisons their descriptions or concerns are based on. In screening inventories parents are asked about their comparisons in a general way, for instance whether the child’s development has been late, average or early. At the interviews in study IV, the parents did not explicitly mention whether they had compared their children with others, but the comparisons were implicit. The interviewer then asked the parents about this. In connection the parents spoke of emotions concerning parenthood. Even though all children had motor difficulties, only some parents had concerns and felt worried or uncertain. Glascoe (23) stated that almost all parents had concerns about their children, but when the parents had concerns in multiple areas it was more likely that their children had a developmental delay. In study IV most parents who reported anxiety and uncertainty in parenthood had children with definite motor difficulties. Concerns in multiple areas were not expressed among the few parents who reported anxiety and uncertainty and whose children had borderline motor difficulties.

Professionals may look upon parents whose children have motor difficulties as co-therapists. One role of the professionals is to help the parents of children with motor difficulties to see with a therapist’s eye, to know how to work on successful approaches in learning motor tasks so that the child feels secure and competent (10, 31, 32, 62). Rodger (73), on the other hand, states that the primary role of parents is to love, care, and have the responsibility for their children, but that parents typically are both willing and fully capable of carrying out training programmes for their children. Study IV showed that especially parents whose children had definite motor difficulties already supported their children physically in naturally occurring situations or by encouraging training. However, there were parents whose children were unwilling to participate in physical activities. Some of these parents said that the children were not motivated, or unwilling, or lazy. These parents might need to see their children through the therapist’s eye and to observe how to teach the children successful approaches in motor learning situations, as stated by Hamill (31). The group motor skill intervention evaluated in study II had an effect on motor skills only in children with borderline motor difficulties. Possibly the effects should be evaluated not only in terms of motor skills, but also regarding the question whether after the group motor skill intervention the parents are able to create a successful motor learning situation, or whether the children more frequently participate in physical activities.

**Participation in physical activity**
Children may want to participate in physical activities for both social and physical reasons. They may feel they know the rules of how to join in a game
and want to do what their peers do. Perhaps they have the physical skills to offer the group and feel competent, or adults have encouraged them, or they want to participate because they feel a motivational climate and enjoyment in performing the activity. There is a delicate balance between having the physical skills and having the social skills to participate in physical activities (70, 84). Previous research (61, 14) has shown that some children with motor difficulties at long-term follow-ups have many friends and seem to be clumsy but well-adjusted teenagers, while others do not. In the present work social skills were not investigated.

Although the perception of one's own competence is considered to be associated with participation in activities (6, 12, 56), the correlation has not been presented as significant (92). Approximately fifty per cent of children diagnosed as having motor difficulties before school start continue to have these difficulties later on (11, 19, 37, 60). The results of study V also showed that the majority of children who at age 5 to 6 had definite motor difficulties remained in the same category of motor difficulties when 7 to 8 years old. According to their parents, most of the 7- to 8-year-old children with definite motor difficulties did not want to participate in physical activities, while most children who at this age had become free from motor difficulties did want to take part. However, in both groups there were children with high and low self-perceived physical competence, so perception of competence did not seem to be connected with their willingness to participate.

Previous research (6) has also shown that adult encouragement is a predictor of participation in physical activity. Adult encouragement promotes vigorous physical activity in young adolescents both directly and indirectly through perceived competence. In study IV, parents whose children had definite motor difficulties were specially encouraging to their children in physical activity. Whether encouragement from parents makes the children participate more frequently in physical activity is less well known. However, in an investigation of 9-year-old children Sallis et al. (77) found that parents who played with their children had more active children, while verbal encouragement to be active was not effective.

A positive attitude on the part of a child towards physical activity, so that the exercise feels enjoyable, affects his willingness to participate (26, 35). Also, results of recently published studies (9, 86) indicate that school children’s perception of success and enjoyment in physical education predict participation in non-compulsory physical education at higher levels. When the physical educator in study II reported that all the children in the experimental group had fully participated in the motor activities, she commented that several of the children had to be persuaded to try them. Furthermore, the educator remarked
that when the children had successfully accomplished an activity, they practised it with pleasure. In the same study the parents commented that after the intervention their children were more self-assured and confident when introduced to a new activity. In children with persistent motor difficulties and in those who have to practise for a long time to achieve new motor competence, it seems especially important to create a motivational climate and an enjoyable training situation. In such cases the attention is focused on having fun, so that the children want to continue to participate even though the improvement in motor skills takes time. Professionals promoting exercise should concentrate not only on the development of motor skills, but also on helping physically awkward children to enjoy the motor activity (9, 94). To increase the effectiveness of motor skill interventions, more research should be directed towards a better understanding of the predictors of later participation in physical activity and towards interventions that effect change in these predictors (3, 26).

Problems to consider
Primary prevention in the child health surveillance programme in Sweden includes parental support and health education (7). Parents whose children have motor difficulties may feel worried and uncertain. One question to consider is the views of the parent and the professionals concerning the role of the parent as a co-therapist, and the possible positive and negative effects of this role on the child and family. Secondary prevention in the surveillance programme includes early identification of disorders, developmental delay and behavioural problems (7). At the level of specialist assessment the children’s difficulties need to be characterised more precisely, so that there is consistency across observers and localities as to who should receive services. One problem concerning the exact characterisation of children with DCD is whether their difficulties permit precise identification. In this thesis emphasis has been placed on describing and assessing motor difficulties from different perspectives. Today’s lack of precise identification tools in different areas should not prevent the professional, parent or child from discussing essential information also in these areas. Another problem concerning the precise characterisation of children with DCD is whether the difficulties can be distinguished on the basis of what is judged as “normal”. All of the children in the present studies had motor difficulties at the age 5 to 6, but none were considered to need extended paediatric rehabilitation services. At the follow-up at age 7 - 8 some of the children were now receiving such extended services, while others were judged not to have motor difficulties any longer. In this context one problem to consider is gender differences and whether it may be stated that most girls who have motor difficulties when 5 to 6 years old will continue to have them, while more boys will grow out of them.

Nevertheless, on the basis of the results of studies I to V the following conclusions can be drawn and recommendations made:
Conclusions

• Motor skill intervention is most effective (a) when applied to children with DCD over the age of 5 years, (b) when the Specific Skills theoretical approach is used, (c) when the intervention is conducted in a group setting or as a home programme, and (d) when carried out at least three to five times per week.

• The parents’ descriptions of the motor development and motor status in their children when 7 to 8 years old is a good indicator of the children’s actual motor status at that age.

• Group motor skill intervention may have positive effects in children with DCD with borderline motor difficulties.

• In a short perspective children who when 5 to 6 years old have motor difficulties consistent with DCD and who score at the 5th percentile or below in the Movement ABC motor test, seem to need active support in enjoyable motor learning situations to reduce unwillingness and displeasure, and to increase the amount of practice.

• Parents whose children have definite motor difficulties, in particular, may already be actively training their children and may feel anxious and uncertain in parenthood.

• Self-perceived competence seems to be unaffected in young children with DCD, since 5- to 6-year-old pre-school children with DCD were found to be similar to peers of the same age regarding self-perception of competence in areas concerning school, peer relations and motor skills.

• Group motor skill intervention in these young children with motor difficulties may have an effect on their awareness of their motor competence.

Recommendations

• Professionals should explicitly ask the parents about their comparisons between their children and other children regarding development and learning.

• Those parents who state that their children are unwilling to participate in physical activities, or have little experience in successful training, may need information and the opportunity to observe training organised to encourage motor learning and development.

• For children with definite motor difficulties, non-specific group motor skill intervention once weekly cannot be recommended. These children may need and benefit from more specific and individualised intervention performed in a group setting or as a home programme and with a higher frequency.

• For children with borderline motor difficulties non-specific group motor skill intervention can be recommended. When deciding whether the child should participate in such intervention or not, the child’s reactions after trial participation should guide the parents and trainers.
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REFERENCES


