European Academy for Childhood Disability (EACD): Recommendations on the definition, diagnosis and intervention of developmental coordination disorder (long version)*

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ORGANIZATIONS AND REPRESENTATIVES

These recommendations were approved at two consensus conferences in Maulbronn (Germany) (26/27 March 2010 and 15/16 July 2010) with representatives from the the German and Swiss medical and therapeutic societies listed below and supervised by the Association of the Scientific Medical Societies in Germany (AWMF, members comprising 154 specialty societies). The AWMF represents Germany in the Council for International Organizations of Medical Sciences (for further information see http://www.awmf.de).

The key recommendations of the clinical practice guideline on developmental coordination disorder (DCD) for Germany and Switzerland are identical to the recommendations on DCD agreed upon by an expert panel initiated by the EACD. The recommendations have been discussed with the European Academy of Childhood Disability (EACD). The EACD considers the present Swiss–German guideline as recommendations for the definition, diagnosis, assessment, and intervention of DCD in other countries.

The participants were as follows.

International representatives

Rainer Blank (Chair of the Scientific Committee of the EACD)
Hans Forssberg (Chair of the EACD)

European panel of experts

The recommendations were approved by a European panel of experts at the EACD meeting in Brussels, 26 May 2010 and through further Delphi rounds.

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TEAMS, ADVISORY BOARD, COORDINATION

Coordination of the specific sections of the clinical practice guideline

'Underlying mechanisms': P Wilson (Australia); 'Consequences', 'Comorbidity', 'Definition and assessment': R Blank (Germany); 'Treatment': B Smits-Engelsman (the Netherlands)

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International experts

The full guideline process was consistently advised by international experts in the field:

B Smits-Engelsman (Physiotherapist, the Netherlands); H Polatajko (Occupational therapist, Canada); P Wilson (Neuropsychologist, Australia); R Geuze (Clinical physicist/neuropsychologist, the Netherlands); The clinical practice guideline on DCD for Germany and Switzerland has been approved by representatives of the following professional societies (not yet confirmed by the boards of the associations).

*This long version of the recommendations is without country specific sections (implementation strategy and quality management). Terminology in this document is consistent with that of the International Classification of Functioning (ICF).

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Medical societies
Neuropaediatric Society for German-speaking countries (lead society); German Society of Child and Adolescent Medicine; German Society of Social Paediatrics and Adolescent Medicine; German Society of Child Psychiatry and Psychotherapy; Swiss Society for Developmental Paediatrics; Forum Praxispädiatrie, Switzerland

Therapist societies
German Association of Occupational Therapists; Swiss Association of Occupational Therapists; Zentralverband Physiotherapie (Germany); Physiotherapia Paediatrice, Schweizerische Vereinigung der Kinderphysiotherapeutinnen; Motopädenverband (Germany)

Patient representatives
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Professional representatives (Germany, Switzerland)
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J Buchmann (German Society of Child Psychiatry and Psychotherapy)
A Jagusch-Espei (German Association of Occupational Therapists)
O Jenni (Swiss Society for Developmental Paediatrics, SGEP, Swiss Society of Paediatrics SGP)
M Linder-Lucht, V Mall (German Society of Child and Adolescent Medicine)
A Oberle (German Society of Social Paediatrics and Adolescent Medicine)
R Schmid (Resident Paediatricians' Association of Germany)
J Seeländer (German Association of Physiotherapists)
F Steiner (Forum Praxispädiatrie, Switzerland)
H Trillen-Krayenbühl (Ergotherapieverband, Switzerland)
R Werthmann (Deutscher Motopaedenverband)

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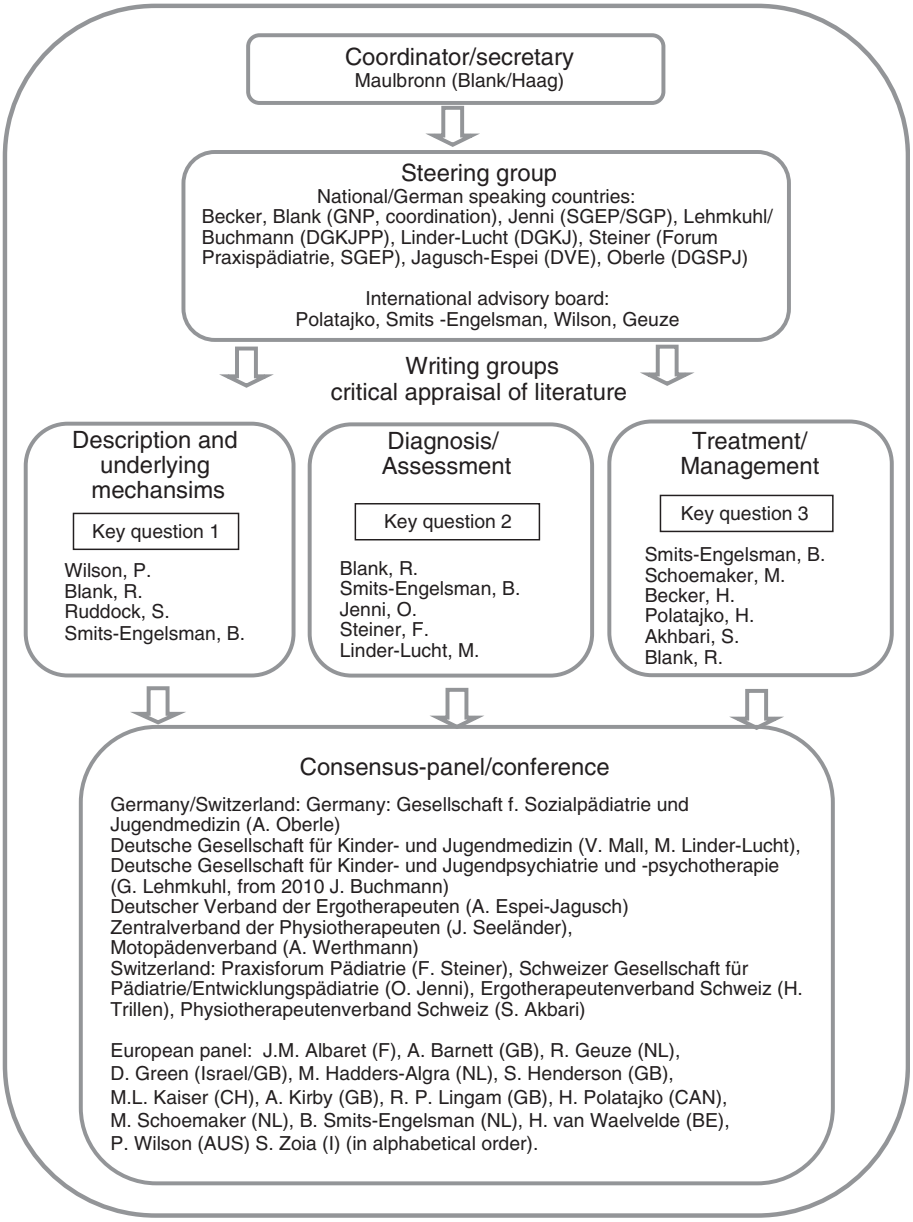
Duration of the validity
The clinical practice guideline was agreed on and written in March 2011. It is valid until the next revision, at the latest until March 2016. A revision is planned about every 3 years by the representative group and the international advisory board. In case of new knowledge or experience that have considerable influence on the recommendations of this clinical practice guideline, the representative group and, if necessary, the international advisory board will rapidly produce the latest information.

Names and roles of the guideline group and consensus panel



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PUBLICATION DATA
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ABBREVIATIONS

ADHD	Attention-deficit–hyperactivity disorder
ADL	Activities of daily living
ASD	Autistic spectrum disorder
AWMF	Association of the Scientific Medical Societies in Germany
BOTMP(-2)/SF	Bruinincks–Oseretsky Test of Motor Proficiency (2nd revision)/short form
CO-OP	Cognitive-orientation to occupational performance
CPG	Clinical practice guideline
CSAPPA	Childrens self-perceptions of adequacy in and predilection for physical activity
DCD	Developmental coordination disorder
DCD-Q(-R)	DCD-Questionnaire (-revised version)
DSM(-IV)(-TR)	Diagnostic and Statistical Manual (Fourth Edition) (Text Revision)
EACD	European Academy of Childhood Disability
GCP++	or + Good clinical practice (recommendation based on strong consensus: ++, >95% of the participants; +, 75–95% or the participants of the nominative group process)
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HAWIK/WISC(-IV)	Hamburg-Wechsler Intelligence test for children (Wechsler Intelligence Scale for children (IVth revision)
HRQOL	Health-related quality of life
ICD	International Classification of Diseases
ICF	International Classification of Functioning
LOE	Level of evidence
M-ABC(-2)	Movement Assessment Battery for Children (-second revision)
M-ABC-C	Movement Assessment Battery for Children – Checklist
NTT	Neuromotor task training
PMT	Perceptual motor training/therapy
SDDMF	Specific developmental disorder of motor function
SIT	Sensory integration/sensory integration therapy
TAC	Trouble de l'acquisition de la coordination
ZNA	Zuerich Neuromotor Assessment Battery

1 INTRODUCTION

1.1 Organizational background

This clinical practice guideline on developmental coordination disorder (CPG–DCD) for German-speaking countries, particularly Germany and Switzerland, is strongly in accordance with the European recommendations of the European Academy of Childhood Disability (EACD) from May 2010 (Brussels) and an international consensus, the International Leeds Consensus (2006).[1] It was formed by a nominal group-consensus process chaired by an independent representative from the Association of the Scientific Medical Societies in Germany (AWMF). The AWMF represents Germany in the Council for International Organizations of Medical Sciences. The CPG–DCD was initiated by the Neuropaediatric Society for German-speaking countries. It funded the second and third consensus conference in Germany. The first consensus conference was connected with an international symposium in Maulbronn, Germany and funded by the Child Centre Maulbronn. The financial responsibilities were not undertaken by any other party.

The development of the CPG–DCD took place between spring 2008 and autumn 2010. The systematic review of the literature related to the key questions was first performed in autumn 2008 and then updated in January 2010 (reviewing all relevant literature from 1995 to January 2010). The following panels were involved in the development of the CPG–DCD: (1) national experts in the field; (2) international experts and an advisory board; (3) national representatives of professional groups; (4) a patients' representative from a parent organization.

Because of a lack of research and recognized experts on DCD in German-speaking countries, it was considered necessary to involve a board of international experts. As DCD is variously defined in different countries, it was also necessary to initiate an international consensus to confirm and/or modify the Leeds Consensus.

The CPG–DCD contains the essential elements of systematic guideline development published by the AWMF. The consensus was obtained in a formal nominative group process. This was based, wherever possible, on an evidence-based literature search. The recommendations were made in relation to expected costs and benefits, for example intervention methods using more sessions with the same outcome received lower recommendation levels than methods requiring fewer sessions. The goals of assessment and interventions were carefully analysed with respect to the International Classification of Functioning (ICF).

The methodological process was in accordance with a previous report on an S3-guideline (an S3-guideline is the highest quality standard of evidence-based practice recommendations approved by the AWMF).[2]

The present document is the long version of the CPG–DCD. Further documents are a short version (German), a version for Parents and Teachers (English/German) and a pocket version (algorithm; English and German). As a large proportion of the target group are children below the age of 8 years, the intention to write a child version has not been implemented.

1.2 General goals of the CPG–DCD

The general goals of this guideline are the following: (1) to determine and prioritize key questions on aetiology, diagnosis and intervention; (2) to raise high-priority practice questions; (3) to provide knowledge on the best evidence-based practice; (4) to point out research gaps; (5) to define individual diagnostic and intervention strategies based on clinical decision rules and evidence-based knowledge; (6) to make recommendations for a variety of different disciplines and to define their roles within clinical practice; (7) to recognize an interdisciplinary approach with physicians of different disciplines and therapists; (8) to identify specific national aspects, for example concerning the use of the International Classification of Diseases, 10th revision (ICD-10) compared with the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV); (9) to provide an

effective implementation strategy of the guideline by involving all medical and paramedical organizations relevant in assessment and treatment; (10) to identify possible barriers for implementation; (11) to provide a basis for clinical training and for implementation in quality management systems.

In addition, specific goals of the CPG–DCD are the following: to improve the identification of children with DCD; to increase the use of effective treatments and reduce the use of ineffective treatments; to decrease the burden of the disorder and increase quality of life; to improve performance of everyday activities and participation at home, school, and at leisure; to improve personal and environmental resources; to improve access to services, in particular healthcare services; to help clarify responsibilities and propose models of cooperation among the various relevant professionals, for example by defining clinical pathways; to help prevent long-term consequences of DCD, for example by timely, effective intervention; to raise community awareness of DCD.

As with every CPG, the CPG–DCD is not a rule of what to do or how to do in a legal sense. It cannot be a basis for legal sanctions.[3,4]

The CPG–DCD has been developed on the basis of the methodological recommendations of the AWMF and the German Instrument for Methological Guideline Appraisal.

1.3 Target audience

The clinical practice guideline may be used by healthcare professionals involved in the care of children with confirmed or suspected DCD (physicians, therapists), and by parents and nursery nurses, teachers, or other educational professionals (the adapted version).

To support the application of the CPG in practice, a short version of the guideline, a table of all recommendations with levels, a flowchart with links to the recommendations, and a version for parents, teachers, and nursery nurses will be provided (available from: www.awmf.org/leitlinien/detail/ll/022-017.html).

2 TARGET GROUP, SCOPE, PARENT EXPECTATIONS

2.1 Target group

The CPG–DCD should apply to children with long-standing, non-progressive problems of specific motor skill performance, not attributable to any other known medical or psychosocial condition. Children may suffer from motor problems for which the guideline does not apply such as cerebral palsy, neurodegenerative disorders, traumatic brain injuries, inflammatory brain diseases, toxic and teratogenic disorders, malignancies, any motor problem due to other diagnosed medical conditions that may explain the poor motor performance. Children with mental retardation are generally not identified as having DCD because of assessment difficulties (pragmatic reasons). These children, however, may also have symptoms of poor motor coordination. Therefore, general recommendations for treatment indications and specific intervention methods may also be applied to the group of children with mental retardation, though the research so far has excluded these children from evaluation.

2.2 Clinical relevance

DCD is a frequently occurring disorder with estimates of 5 to 6% being the most frequently quoted percentage in the literature.[5,6] It is a chronic disorder with considerable consequences in daily life. At least 2% of all children with normal intelligence suffer severe consequences in everyday living, and a further 3% have a degree of functional impairment in activities of daily living or school work.[7] Nonetheless, DCD is largely underrecognized by healthcare and educational professionals.[8,9]

On the other hand, there are considerable costs for long-term treatment, with questionable efficacy. According to the 'Heilmittel-Report 2008', the treatment of 'sensorimotor disorders' ranked number one within occupational therapy interventions with 2.5 million therapy sessions (costing almost €125 million) in 2006 reported by the AOK, the largest health insurance company in Germany,[10] alone. About €400 million are spent for sensorimotor therapy in occupational therapy.[10] This is almost 50% of all occupational therapy interventions and over 90% of all occupational therapy sessions with children and adolescents under 15 years.

2.3 Scope

There are several questions and issues concerning DCD. Major problems arise from the current lack of consensus on the following: definition and terminology (how to define, best name for the disorder); diagnosis and assessment (how to assess for diagnosis, how to monitor during development and treatment); epidemiology (how many diagnosed, undiagnosed cases); outcome and prognosis (what consequences, in which areas of everyday living and participation); underlying mechanisms (developmental and/or learning disorder, poor information processing, etc.); comorbidities (what to treat, barriers to treatment); treatment indication (when and what to treat); intervention methods (which, how long, how intensive).

These questions were the reason for the development of this CPG. The authors of the guideline hope to achieve improvements in the definition (national and international), diagnosis, and assessment of DCD as well as in the treatment indication and specific intervention. Further, the CPG–DCD should help to increase professional attention to this area which is, so far, widely neglected in German-speaking countries. The research on DCD is extremely underdeveloped in these countries: for example, there have been almost no original papers in international journals in the past 10 years coming out of Germany.

2.4 Expectations of the patients' representative

To ensure that the guideline is responsive to the expectations of the children and their parents, a parent organization for children with learning disorders took part in the entire guideline process (Annette Mundt, Parent support group: Selbstaendigkeitshilfe bei Teilleistungsschwaechen). The following expectations were identified: (1) more awareness and recognition of the problem by the community, healthcare professionals, nursery nurses, and parents; (2) improved access to services, particularly healthcare services; (3) establish a clear diagnosis (transparency of diagnostic criteria, explaining the diagnosis, and initiating the necessary examinations); (4) better information about thera-

peutic options and types of therapy for parents; (5) information about effectiveness of intervention with respect to (a) improvement of motor function, (b) improvement of performance in daily activities, (c) improvement of participation, particularly at school; (6) finally, parents expect information on how the guideline is implemented (knowledge translation).

3 KEY QUESTIONS

The guideline group decided to focus on three basic key questions.

1. How is DCD defined? Which functions are impaired in children with DCD?

The definition of DCD was subject to expert consensus. For communication between experts, health professionals, and parents, it was regarded as important to develop a generally recognized definition of DCD based on the ICD-10 (DSM-IV, Text Revision [-TR] in countries where it is the legal basis[11,12]).

The findings of impaired functions or underlying mechanisms were extracted from a systematic literature search. The impairment should reflect the levels of the ICF such as body function and structure (motor, sensory, cognitive function, emotional/affective function), activities of daily living (basic and instrumental), participation (home, school, and community), and personal and environmental factors. The question on impairment does not aim at specific clinical practice recommendations but to increase understanding of the disorder, its severity, and its natural course.

2. How is DCD assessed and monitored? How should children with DCD with and without treatment (natural course) be monitored (qualitative/quantitative aspects)?

Applicability and test criteria of assessment instruments were subject to a systematic literature search and, where not possible, were addressed by experts' opinions and a consensus conference.

The question of how DCD can be identified should be answered by examining the role of medical history and interview, questionnaires, clinical examination, and motor tests. Further, assessment instruments should be discussed with respect to daily living, school/leisure and the role of clinical compared with natural settings.

The answer to how and when to measure progress should reflect levels of body function and structure (e.g. motor functions, sensory, cognitive functions, emotional/affective functions, language functions), and activities of daily living (e.g. self-care, academic performance) and participation (at home, school and community), acknowledging personal and environmental factors.

3. How effective are the treatment methods for DCD?

The treatment efficacy should be answered by systematic evaluation of the literature and, where not possible, answered by a nominative group process during a consensus conference.

As in the key question on assessment, the levels of the ICF should be considered as body function and structure (motor, sensory, cognitive function, emotional/affective function), activities of daily living (basic and instrumental) and participation (home, school, and community), and personal and environmental factors.

Effectiveness should also be discussed with respect to efficiency (cost–benefit).

Further questions of interest

Several further questions were of great interest but could only be addressed to some extent in this guideline. Which interactions do occur by treating comorbid conditions (e.g. pharmacological treatment with stimulants of children with attention-deficit–hyperactivity disorder [ADHD])? Are there barriers to access healthcare services or treatment services for DCD (e.g. parental education, language, cultural, geographic, socio-economic status, health services policies)? What are the views and opinions about DCD of parents, patients, and teachers?

4 AREAS OF INTEREST AND RELEVANCE OF OUTCOMES

4.1 Areas of interest

Based on the key questions, the identified main areas of interest for clinical recommendations are identification/diagnosis, treatment indication, and treatment outcome.

Using a democratic group process (blind voting) the guideline group decided on the relevance (priorization) of target variables with respect to the systematic literature search (1, very important: critical for making a decision; 9, not important at all [e.g. surrogate, no evidence for correlation with hard endpoint]). Relevant target variables are shown in Tables I and II.

5 EVALUATION OF THE LITERATURE: METHODOLOGICAL BASIS

5.1 Recommendations based on evidence

Original papers addressing of key questions 2 (assessment) and 3 (treatment) were categorized according to the level of evidence using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) and Oxford systems. In contrast to intervention studies, an established grading system for the different types of diagnostic study does not exist. Therefore, the GRADE system and the Oxford definition had to be modified and adapted (see Table VII in Appendix I). In some studies the level of evidence (LOE) had to be adjusted according to specific criteria. The level of evidence was decreased in cases of serious (−1) or very serious (−2) limita-

Table I: Target variables for outcome

Body function and structure	Motor performance, basic motor skills
Personal factors	Quality of life (well-being, satisfaction), coping
Activities	Activities of daily living, school performance, activity limitation
Participation	Social integration, social burden of disorder, sports participation
Environmental factors	Socio-economic resources (nursery/school facilities, financial resources, therapeutic resources, availability of sports club, etc.), coping/compensation (by family, teachers, adaptive materials, sport instruments, etc.)

Table II: Relevance of outcomes: areas of interest and target variables as rated by the guideline group

	Diagnosis	Treatment indication	Treatment outcome
Body function and structure	1		
Deficit in motor performance and psychomotor functions			
Poor basic motor skills and perceptual/motor functions			
Activities	1	1	1
Activities of daily living (self-care, etc. [basic activities of daily living {ADL}[a], school performance, instrumental ADL[b])			
Participation		1	1
Social integration (e.g. sport participation)[c]			
Personal factors		1	
Coping (individual resources, intelligence, etc.)			
Quality of life, well-being, satisfaction			
Environmental factors		1	
Socio-economic resources (nursery/school facilities, financial resources, therapeutic resources, availability of sports club, etc.)			
Coping/compensation (by family, teachers, adaptive materials, sport instruments, etc.)			

1, Very important: critical for making a decision. [a]Basic ADL (self-care, toileting, eating/drinking, etc.). [b]Instrumental ADL (using a pen, scissors, playing with toys, etc.). [c]Possible participation restriction as a consequence of activity limitations.

Table III: Levels of recommendations

Level of evidence	Recommendation for/against	Description
1	'should', 'should not', 'is not indicated'	A
2	'may', 'may not'	B
3 or 4	'may be considered' or 'do not know'	0

tions to study quality, important inconsistency (−1), imprecise or sparse data (−1), high probability of reporting bias (−1). The level of evidence was increased in case of consistent evidence from two or more observational studies with no probable confounders (+1), evidence of a dose response gradient (+1), all probable confounders would have reduced the effect (+1). The levels and strength of recommendations used is directly related to the level of evidence (Tables III and IV).

5.2 Recommendations based on formal consensus

Several recommendations are based on a formal consensus within a nominative group process, particularly those dealing with definition. Recommendations based on group consensus (good clinical practice [GCP]) are included in the guideline. A strong agreement (strong consensus ≥95%; if only 10 or fewer participants were present, ≥90% agreement) is marked as GCP++; a moderate agreement (consensus ≥75–95%; if only 10 or fewer participants were present, ≥90% agreement) is marked as GCP+.

6 EPIDEMIOLOGY

Current prevalence estimates for DCD range from 5 to 20%, with 5 to 6% being the most frequently quoted percentage in the literature.[13] It is generally recognized that these children have problems with motor skills that are significant enough to interfere with both social and academic functioning.[6] Kadesjo et al.[6] found a prevalence rate of 4.9% for severe DCD and of 8.6% for moderate DCD in a population-based study of 7-year-old children in Sweden. The Avon Longitudinal Study of Parents and Children study found 1.8% of children aged 7 years had severe DCD, with another 3% defined as having probable DCD with consequences for everyday life.[7] We note that epidemiological information is largely dependent on how strictly selection criteria are applied.

DCD is more common in males than in females, with male:-female ratios varying from 2:1 to 7:1.[6,7] Although DCD is relatively common, it is still largely unrecognized by healthcare professionals and nursery nurses.[8,9] Motor performance difficulties of children with DCD are often viewed as 'mild' and, thus, not warranting attention compared with the needs of children with more severe impairments such as cerebral palsy.

7 DEFINITION, DESCRIPTION, CONSEQUENCES, OUTCOME, UNDERLYING MECHANISMS OF DCD

7.1 Definition

DCD occurs across cultures, races, and socio-economic conditions. The disorder is idiopathic in nature, although several hypotheses for the cause of DCD have been recently proposed (see section 7.2). In the clinical practice and the scientific community, there are still many ambiguities in the definition and the diagnosis of DCD. Evidence suggests that DCD is a unique and separate neurodevelopmental disorder which can, and often does, co-occur with one or more other neurodevelopmental and neurobehavioural disorders. Commonly, these disorders include ADHD, specific language impairment, specific learning disabilities, autistic spectrum disorder (ASD) and developmental dyslexia or reading disability. Some of these comorbidities are so strongly associated with DCD that DCD has even been regarded as a part of these disorders (e.g. ASD and DCD is not allowed according to DSM-IV classification; furthermore, the concept of deficits in attention, motor control and perception[14,15] includes aspects of ADHD and DCD).

Because key question 1 relates to this topic, definitional recommendations are made based on a nominative group process.

7.1.1 Definition according to ICD-10: specific developmental disorder of motor function (SDDMF) (F82.0 or F82.1)

According to the ICD-10 (revised version 2007), DCD, called SDDMF, is defined as a 'disorder in which the main feature is a serious impairment in the development of motor coordination that is not solely explicable in terms of general intellectual disability or of any specific congenital or acquired neurological

Table IV: Strength of recommendation based on level of evidence

Strength of recommendation	Description	Criteria
A (Aneg)	Strongly recommended that clinicians (do not) routinely provide the intervention/assessment to eligible residents	Good quality of evidence and substantial net benefits
B (Bneg)	Recommended that clinicians (do not) routinely provide the intervention/assessment to eligible residents	Fair quality of evidence and substantial net benefit or Good quality of evidence and moderate net benefit or Fair quality of evidence and moderate net benefit
0	No recommendation for or against routine provision of the intervention/assessment Insufficient evidence for recommendation of the intervention/assessment	Good quality of evidence and small net benefit or Fair quality of evidence and small net benefit Poor quality of evidence (conflicting results; balance between benefits and risks difficult to determine; and poor study design)

The Canadian Guide to Clinical Preventive Health Care. Recommendations by Strength of Evidence. Accessed March 12, 2003.
US Preventive Services Task Force. Translating evidence into recommendations. Accessed March 6, 2003. http://qmweb.dads.state.tx.us/falls/StrengthRecomm.htm

disorder. Nevertheless, in most cases a careful clinical examination shows marked neurodevelopmental immaturities such as choreiform movements of unsupported limbs or mirror movements and other associated motor features, as well as signs of impaired fine and gross motor coordination.'

The definition excludes abnormalities of gait and mobility (R26–), isolated lack of coordination (R27–), and motor impairment secondary to mental retardation (F70–F79) or to other medical and psychosocial disorders.

The definition of DCD according to ICD-10 requires that the diagnosis is not solely explicable by mental retardation or any specific congenital or acquired neurological disorder.

7.1.2 Definition according to DSM-IV

DCD is included in the section 'Learning disorders' and the section 'Motor skills disorders' (315.4 Developmental coordination disorder). The term was endorsed in the International Consensus Meeting in London/Ontario, Canada, in 1994.

DCD according to DSM-IV is defined by the following four criteria.

A. Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. The disorder may be manifested by marked delays in motor milestones (e.g. walking, crawling, sitting), dropping things, by 'clumsiness' and by poor performance in sports or poor handwriting.

B. The disturbance described in criterion A significantly interferes with academic achievement or activities of daily living.

C. The disturbance is not due to a general medical condition (e.g. cerebral palsy, hemiplegia, or muscular dystrophy) and does not meet criteria for a pervasive developmental disorder.*

D. If mental retardation is present, motor difficulties are in excess of those usually associated with mental retardation.

Coding note If a general medical (e.g. neurological) condition or sensory deficit is present, code the condition on axis III (DSM-IV).

Looking at original papers, the term 'DCD' was used in 52.7%, 'clumsy children' in 7.2%, and 'developmental dyspraxia' in 3.5% of articles (see systematic review from January 1995 to December 2005 by Magalhaes et al.[16]). In 23.5% of the articles other terms were used. In the Leeds Consensus,[1] the term DCD was favoured.

The existence of subtypes of DCD is likely, but could not be consistently confirmed by research evidence (see, for example, review by Visser[17]).

7.1.3 Other definitions

The Dyspraxia Foundation (UK) recommends the use of the term 'developmental dyspraxia'.[18] This term defines dyspraxia as 'an impairment or immaturity of the organization of movement' and in many patients there are associated problems with language, perception and reasoning. A distinction between developmental dyspraxia and DCD has been postulated.[19] Indeed, a dysfunction in the process of forming ideas, motor planning, and execution can be found in DCD. However, the term 'dyspraxia' has not become recognized as separate entity or subgroup of DCD (see section 7.2).[20,21]

Another definition comes from Sweden. Gillberg et al.[15] have argued for the presence of a syndrome called deficits in attention, motor control, and perception (DAMP). However, this concept has not become recognized outside Sweden.

Non-verbal learning disability is believed by some to be a neuropsychological disability.[22] Although it has been studied for the past 30 years,[22] it has not yet been included as a diagnostic category in the DSM-IV-TR. Many characteristics associated with non-verbal learning disability are similar to

*The Leeds Consensus Statement.[1] This considers the high incidence of comorbidity within neurodevelopmental disorders and that it is inappropriate to exclude the possibility of a dual diagnosis of DCD with a pervasive developmental disorder/autism spectrum disorder (p6).

those that describe other, more 'established' disorders, such as Asperger syndrome, specific learning disabilities, and DCD.

7.1.4 Recommendations on the definition of DCD

At present, the DSM-IV criteria are better defined than the ICD-10 criteria. The Leeds Consensus group (2006) agreed to re-confirm the London consensus and accept the DSM-IV-TR[11,12] as the most suitable set of diagnostic criteria that are currently available. The consensus of the guideline group also decided to use the DSM name DCD and their criteria. In Table V the official terminology for DCD is given as it applies to other languages.

Recommendation 1 (GCP++)

The term developmental coordination disorder (DCD) should be used to refer to children with developmental motor problems in countries which adhere to the DSM-IV-TR classification. In countries where ICD-10 has legal status, the term specific developmental disorder of motor functions (SDDMF) (F82, ICD-10) should be used.

Comment

The term DCD is used because this wording is well recognized in the English literature. It is taken from the DSM classification. However, in several European countries, the ICD-10 has legal status. Thus, the terminology of the ICD-10 must be used in those countries. Accordingly, the term SDDMF is added in brackets throughout this document (for the purposes of countries using ICD-10 terminology). Moreover, the following recommendations were also related to the ICD-10. Where concepts differ between DSM and ICD-10, specific comments are provided (specific recommendations 2a and 6a, see Supporting Information, section 13.7).

Recommendation 2 (GCP++)

Criteria for the diagnosis of DCD (SDDMF)

I. Motor performance that is substantially below expected levels given the child's chronological age and appropriate opportunities for skill acquisition.

The poor motor performance may manifest as (1) poor balance, clumsiness, dropping or bumping into things, or (2) persistent difficulty in the acquisition of basic motor skills (e.g. catching, throwing, kicking, running, jumping, hopping, cutting, colouring, printing, handwriting).

Marked delays in achieving developmental motor milestones (e.g. walking, crawling, sitting) may be reported.

Table V: Terminology for developmental coordination disorder according to language

Language	Disorder	Abbreviation
English	Developmental coordination disorder	DCD
German	Umschriebene Entwicklungsstörung motorischer Funktionen (specific developmental disorder of motor function)	UEMF (SDDMF)
French	Trouble de l'acquisition de la coordination	TAC

II. The disturbance in criterion I significantly interferes with activities of daily living or academic achievement (e.g. self-care and self-maintenance, handwriting, academic/school productivity, pre-vocational and vocational activities, and leisure and play).

III. An impairment of motor coordination that is not solely explainable by mental retardation. The disturbance cannot be explained by any specific congenital or acquired neurological disorder or any severe psychosocial problem (e.g. severe attentional deficits or severe psychosocial problems, e.g. deprivation).

Comment

This CPG–DCD aims to minimize differences in interpretation and classification between ICD-10 and DSM-IV, because the disorders are considered to represent similar conditions. Criterion III is largely consistent with criteria C and D in the DSM-IV (the exception is the exclusion of ASD see recommendation 6).

Comments

Clarification of criterion III 1. DCD (SDDMF) should not be diagnosed if (1) motor performance cannot be assessed by a motor test (e.g. because of mental retardation or a medical disorder) or (2) if, after a comprehensive assessment including clinical history, examination and consideration of teacher and parent reports, the motor dysfunction can be explained by another condition including a neurological or psychosocial disorder or severe mental retardation.

In the comments of F82 (ICD-10), it is mentioned that some children with DCD (SDDMF) may show marked 'neurodevelopmental immaturities' such as choreiform movements of unsupported limbs or mirror movements and other associated motor features. According to the current literature and clinical practice experience, the roles of these motor features are still largely unclear and need further evaluation.

2. DCD (SDDMF) and mental retardation. The problem of diagnosing DCD (SDDMF) in children with learning disability (mental retardation) was discussed intensively within the guideline group and within the European consensus group. It was, however, recognized that defining a specific IQ below which the diagnosis of DCD (SDDMF) is precluded seems artificial. Given the complexities of arbitrating between cut-offs and determining discrepancy scores, it is recognized that a categorical decision (above or below a specific IQ level) may be extremely difficult. Looking at a meta-analysis on underlying mechanisms of DCD referring to key question 1 of the CPG (see section 7.2) a specific IQ level does not seem to be helpful to distinguish between children with DCD and children with coordination problems due to mental retardation.

It was agreed that the motor dysfunction should be defined as DCD (SDDMF) if the other criteria are fulfilled and if clinical history and examination cannot explain the motor problems and their impact on daily activities by cognitive status.

3. DCD (SDDMF) and coexisting diagnoses. It is widely recognized that children with DCD (SDDMF) often have

coexisting diagnoses. It should be considered that ADHD, ASD or conduct disorders may interfere with motor performance and testing, as well as with activities of daily living making motor assessment of children with DCD (SDDMF) difficult (see recommendation 5).

Recommendation 3 (GCP++)
The diagnosis of DCD (SDDMF) should be made within a diagnostic setting by a professional who is qualified to examine the specific criteria.

Comment
This may require a multidisciplinary approach.

Recommendation 4 (GCP++)
Concerning criterion II: the complete assessment should include consideration of activities of daily living (e.g. self-care and self-maintenance, academic/school productivity, prevocational and vocational activities, leisure and play) and the views of the child, parents, teachers, and relevant others.

Comments concerning criterion II
By definition, activities of daily living imply cultural differences. When applying this criterion, it is therefore crucial to consider the context in which the child is living and whether the child has had appropriate opportunities to learn and practice activities of daily living (see criterion I 'previous opportunities for skill acquisition').

Establishing a direct link between poor motor coordination and academic achievement is complex. However, the specific skill of handwriting is usually affected, and is known to adversely influence academic achievement and should therefore be assessed.

The complete assessment should reflect culturally relevant developmental norms.

Recommendation 5 (GCP++)
Children with DCD (SDDMF) having performance deficits in specific areas of motor performance (e.g. gross motor or fine motor dysfunctions [manipulative skills]) should be classified according to the ICD subgroups (gross motor dysfunctions F82.0 or fine motor dysfunctions F82.1).

Comment
For countries using ICD-10: Graphomotor disorders are specified as a subtype of DCD (SDDMF) by the ICD-10 and classified on the basis of impaired fine motor functions (F82.1). Expressive writing disorders are classified under F81.8 according to the ICD-10. Isolated handwriting problems without additional graphomotor or other fine motor problems may not justify the diagnosis of F82.1.

Recommendation 6 (GCP++)
A dual diagnosis of DCD (SDDMF) and other developmental or behavioural disorders (e.g. ASD, learning disorders, ADHD) *should* be given if appropriate.

Comment
For countries using DSM classification: recommendation 6a (see section 13.7, Supporting Information). Dual diagnosis also serves the setting of priorities for intervention (see statement 3 and Recommendation 18).

Recommendation 7 (GCP++)
Comorbidities should be carefully diagnosed and treated according to established clinical guidelines (e.g. ADHD, autism, dyslexia, specific language impairment).

Recommendation 8 (GCP++)
The onset of DCD (SDDMF) is usually apparent in the early years, but would not typically be diagnosed before 5 years of age.

If a child between 3 and 5 years of age shows a marked motor impairment, even though there have been adequate opportunities for learning and other causes of motor delay have been excluded (e.g. deprivation, genetic syndromes, neurodegenerative diseases), the diagnosis of DCD (SDDMF) may be made based on the findings from at least two assessments performed at sufficiently long intervals (at least 3mo).

Comment
According to the guideline group considerable problems exist for the diagnosis of DCD (SDDMF) in children below 5 years of age for the following reasons.

1. Young children may show delayed motor development with a spontaneous catch up (late developer).
2. The cooperation and motivation of young children for motor assessments may be variable. Thus, test performance may be unreliable and finally result in poor predictive validity (criterion I).[23,24] Nevertheless, a very recent study from Smits-Engelsman et al.[25] indicates that motor assessment by the Movement Assessment Battery for Children – second revision (M-ABC-2) has a very good test–retest reliability also for 3-year-old children.
3. The rate of acquisition of activities of daily living skills is variable in children at kindergarten age. Thus, the evaluation of criterion II of the diagnostic criteria in children under 5 years is unreliable.
4. Finally, there are no reliable data on the value of early intervention in preventing DCD (SDDMF).

The lack of stability of DCD (SDDMF) diagnosed at early ages has been shown with the exception of DCD (SDDMF) in cases with coexisting ASD.[23,24,26]

Nevertheless, the assessment itself may be reliable for example using the M-ABC,[27] repeated assessment within short intervals (e.g. 3wk) are not recommended because of practice effects.[28] A follow-up study underlines that only in definite (severe) cases of DCD being detected before school age is the disorder stable 2 to 3 years later.[29] This supports the recommendation that in 3- to 4-year-old children the fifth centile of quantitative measures like the M-ABC may be used for identification (see recommendation 17).

Comment

The guideline group additionally expresses concerns about the diagnosis of DCD (SDDMF) (first identification of DCD (SDDMF)) after 16 years of age. The criteria for DCD (SDDMF) need to be reconsidered for adults. Although there is a problem with lack of suitable instruments, a diagnosis in adulthood should be possible.

Symptoms must be present in early childhood (but may not become fully manifest until movement challenges exceed limited capacities with respect to context and opportunities).

7.2 Description, underlying mechanisms, clinical findings, consequences, and prognosis

7.2.1 Clinical findings with respect to the level of body functions

The systematic search of the literature identified 23 descriptive studies and 36 studies covering additional aspects like possible consequences of DCD. Further, 131 studies on different underlying mechanisms plus 28 studies covering additional aspects of DCD have been identified.

Some studies describe decreased basic strength and fitness.[30,31] Several studies describe certain deficits in fine motor skills, balance, and/or visuomotor skills.[32–35]

Further studies address the visuospatial dysfunction: O'Brien et al.[36] found evidence for a global spatial processing deficit in children with DCD (SDDMF). Mon-Williams et al.,[37] on the other hand, found difficulties in body-centred spatial judgments (especially limb position) which may lead to an inappropriate relationship between perception and action.

Several studies consider proprioceptive dysfunction,[38,39] especially processing of kinaesthetic information,[40,41] as crucial in DCD (SDDMF). Volman et al.,[42] on the other hand, considered the coupling of different afferent components (visual, proprioceptive, etc.) as deficient, leading to difficulties in maintaining postural stability in action.[42]

Abnormalities in the processing of efferent information were also suggested as underlying mechanisms in DCD (SDDMF)[43–45] as well as deficient inhibition of the pre-cued-induced urge to move attention.[46,47]

Other authors find mainly immature movements in children with DCD (SDDMF) underlining the aspect of development. Thus Mon-Williams et al.[48] found mainly prolonged duration of movements as in much younger children, whereas Missiuna et al.[49] found, especially in writing tasks, not only immature pencil grasps but also slow movements with poor control of distal movements, as can be seen in younger children.

In the past 5 years more refined techniques have allowed a better description of the deficits in DCD (SDDMF). Mackenzie found, that children with DCD (SDDMF) showed no problems with coordination of basic gross-motor tasks (e.g. of coordinating their clapping to their footfalls while marching in place). But the same task coupled with increased variety led to increased problems (mainly associated with the arm movements).[50] This study shows that the more a task demands the integration of different information, the more vulnerable it is. Deconinck[51], on the other hand, found that children with DCD (SDDMF) showed less difficulty in maintaining balance and control of velocity in walking under visual control than without. He found further that children with DCD (SDDMF) showed diverging gait patterns (especially gait length and trunk inclination) from typically developing children, suggesting adaptation of their gait to their poor balance control.

Difficulties in visual memory[52] and deficits in language processing[53] have also been interrelated with DCD (SDDMF).

Underlying organic defects are addressed in the last two studies: Katschmarsky[44] considered a parietal dysfunction. This may relate to the former diagnosis of a 'minimal cerebral dysfunction', which receives some support from the fact that children born preterm are much more likely to develop DCD (SDDMF).[7] Goez et al.,[54] on the other hand, found more often left-handedness than right-handedness in DCD (SDDMF), thus implying a genetic variability.

To prioritize and clarify the main findings from the numerous studies on underlying mechanisms members of the guideline group performed a careful meta-analysis.

From the initial literature search, 128 studies were identified as suitable for a meta-analysis. Within a careful selection process it was important to use studies that permitted a comparison between children with DCD (SDDMF) and typically developing children. From here, studies were categorized according to their relevant theoretical paradigm (e.g. information processing, dynamical systems, cognitive neuroscience, hybrid approach). Then, all dependent measures were listed and coded according to a conceptual scheme that best represents the underlying mechanisms being assessed. Among the studies with critical effect-size estimates ($k \geq 10$), the largest effect sizes were found for kinematic parameters associated with reaching and catching: kinematic catching (r=0.92), and kinematic target-directed reaching within personal space (r=0.82) and outside of personal space (r=0.81) were the highest discriminating measures between DCD (SDDMF) and comparison groups. Large effect sizes were also found for pattern variability during gait (r=0.58), static balance under postural control (r=0.56), and measures of forward modelling including covert orienting (r=0.57) and motor imagery (r=0.50). Moderate effect sizes were found for both visuospatial and verbal working memory (r=0.43 and 0.45, respectively).

Of those categories that yielded high magnitude effect sizes but with $k<10$, high magnitudes were found for forward modelling: motor imagery (r=0.98), and covert orienting that used valid and invalid precues (r=0.83 and 0.83, respectively). Other high effect sizes were found for contralateral (r=0.95) and ipsilateral (r=0.94) target-directed aiming movements.

Taken together, these results suggest that children with DCD (SDDMF) show underlying problems in visual–motor translation (namely inverse modelling) for movements directed within and outside peripersonal space, adaptive postural control, and the use of predictive control (namely forward modelling), which impacts the ability to adjust movement to changing constraints, in real time.

7.2.2 Clinical findings with respect to the level of activities and participation

The systematic search of the literature yielded few studies addressing the level of activities and participation in children with DCD (SDDMF). Only five studies were identified (see Table VIII in Appendix I).

The results can be summarized as follows. Two studies[34,55] address the question of predicting ball flight. Lefebvre et al.[34] found that healthy children could predict ball flight better with increasing age depending on training but 40 children with DCD (SDDMF) could predict ball flight significantly worse than their healthy peers at 5 to 7 years. Deconinck et al.[55] found in a small case–control study of nine male children that those with DCD (SDDMF) adapted as well as healthy male children to temporal structure and velocity of ball flight but showed less opening of the hand and slower closing on the ball than comparisons. They deduced that the male children with DCD (SDDMF) showed more problems in the executive plan rather than visuo-perceptive or action-planning processes. Again this is a very small study group.

Two other studies[56,57] address the question of emotional implications in children with DCD (SDDMF). Cairney et al.[56] found in a large, population-based study that children with DCD (SDDMF) performed more poorly on a simple aerobic task (running) than their healthy peers. At least one-third of the effect was found to be due to their conviction of their own inadequacy. This study shows that emotional factors play a significant role in the participation in everyday life in children with DCD (SDDMF). In a much smaller study (10 male children) Lloyd et al.[57] found differences in cognitive coping strategies for motor planning in different motor tasks (hockey shot and peg solitaire) in children with DCD (SDDMF) compared with typically developing peers. Differences in emotional handling of the task were only seen in the sport specific problem (hockey shot). This interesting finding tends to underline the necessity of supporting children with DCD (SDDMF) in their daily activities rather than treating the underlying condition. As the study group was very small, this question should be addressed again with a more representative sample.

Finally, Pless et al.[58] addressed the measures taken by the involved parents in supporting their children (before the diagnosis is made). They found that parents of children with DCD (SDDMF) are more frequently assisting and encouraging their children in motor tasks but are also more worried concerning the wisdom of their actions.

7.3 Consequences

The systematic search found 30 studies presenting data on the consequences of DCD (SDDMF) in different areas of the ICF. Eighteen studies presented findings at the level of body and mental functions, 20 studies described consequences in activities and participation, 16 studies reported results on personal factors, and 15 studies provided findings about the environment (as defined by the ICF). Because the results of this literature search are not directly relevant for specific recommendations concerning the key questions, only those results in the area of activities and participation are presented (see also Table IX in Appendix I).

There is no doubt that DCD (SDDMF) leads to an impaired functional performance in activities of daily living.[59,60] These children require a higher level of structure and assistance in these activities than their typically developing peers.[61]

The impact of motor coordination problems on physical activity engagements throughout life is influenced by a multitude of factors (social, cultural, physical environment, individual characteristics)[62] but there is evidence that children with DCD (SDDMF) show less physical activity and especially participation in team sports.[63,64] This may lead to poor self-efficacy in adolescents with DCD (SDDMF)[65,66] and lower life satisfaction.[67] Indeed, Piek et al.[68] found a significant correlation between motor ability and anxiety disorders at kindergarten age. Behavioural problems but also problems in social interactions persisted in a long-term follow-up.[69] This affected the whole family system and especially the parents over a long time period[60,69] and leads to concern of the parents about their children's participation in society.[70]

Some studies highlight the negative effect of DCD (SDDMF) on body fitness,[71,72] which is mostly ascribed to less physical activity than in typically developing peers.

7.4 Outcome

There are several studies which addressed the natural course of DCD (SDDMF) (see Table X in Appendix I). There is compelling evidence that DCD (SDDMF) persists well into adolescence[73–77] and persists in an estimated 50 to 70% of children,[77] which is further proof of the independency of this disorder, although it can be associated with other learning or behavioural disorders: In kindergarten age motor problems seem to be associated with language and communication problems.[78,79] These can persist into school age. Kadesjö and Gillberg[80] found restricted reading comprehension in children diagnosed with DCD (SDDMF) at the age of 7. At school age there are further indications that some children with DCD (SDDMF) show poorer outcome in scholastic achievements[81] than their healthy peers, especially in the arithmetic domain.[82] This aspect can be related to the known difficulties of some children with DCD (SDDMF) in the visuo-spatial plane.

Cairney et al.[64] found in a big study group, a correlation between DCD (SDDMF) and subsequent development of obesity in male children, whereas there was no such consequence observed in female children. One explanation may be that the participation in team play activities and sport teams is diminished in children with DCD (SDDMF).[81,83–85] This may also be a reason why long-term participation in social activities is generally reduced.

Concerning coping mechanisms, Causgrove et al.[86] found a higher perceived competence in children with DCD (SDDMF) after physical education classes emphasizing a very motivational climate thus reducing the burden of the disorder.

7.5 Burden for society

There is no doubt that diagnosis and intervenion is costly, both to these children and to society as a whole. The numerous data on consequences and outcome of DCD (SDDMF) clearly underline that DCD (SDDMF) is a burden for society. The marked influence of DCD (SDDMF) on everyday activities and school performance and, secondarily, on social participation as well as the high prevalence indicate that the burden is considerable.

The meta-analysis on underlying mechanisms shows that DCD (SDDMF) is a neurobiological disorder with complex neuropsychological deficits concerning motor imagery, planning, and execution (see section 7.2).

7.6 Comorbidities

There is strong evidence that DCD (SDDMF) is combined with several emotional, social, and specific learning difficulties.[87]

In some children, it cannot always be determined to what extent behavioural problems are co-existing disorders or the consequences of longstanding negative experiences with clumsiness in everyday life. Kaplan et al.[88] question the term 'comorbidity' as there is large overlapping between DCD (SDDMF), learning disorders and ADHD. They prefer the term 'atypical brain development'.

However, the guideline group decided to stick with the term comorbidity as for assessment it seems to be more appropriate to look for the distinct disorders and set priorities for choosing interventions as necessary.

7.6.1 Functional and socioemotional problems in children with DCD (SDDMF)

Regarding socioemotional problems as consequences and outcome, we refer to sections 7.3 and 7.4. The cooccurrence of DCD (SDDMF) and social, emotional, and attential problems are well known.[82,89,90]

7.6.2 Coexisting disorders

ADHD has been found to be the most frequent comorbid disorder to DCD (SDDMF). Several studies – mostly examining clinical samples – suggest a rate of greater than about 50% of comorbidity.[91]

However, data from population-based studies suggest that about half of children with DCD (SDDMF) and half of children with ADHD have combined problems.[6] In a further paper, Kadesjö and Gillberg describe that DCD (SDDMF) diagnosed in 7-year-old Swedish children predicted reading comprehension at the age of 10 years.[80] DCD (SDDMF) itself remained stable at least within 1 year follow-up. In a further population-based study, Kadesjö and Gillberg[92] found that 87% of children with ADHD had comorbidities. ADHD with DCD (SDDMF) seems to be more common in clinical and support groups than in school groups (in contrast to conduct problems, etc.).[93]

A further study underlines the important clinical role of DCD (SDDMF) in the context of ADHD. Rasmussen et al.[94] found in a 22-year longitudinal, community-based follow-up that individuals with ADHD with DCD (SDDMF) had a much worse outcome than individuals with ADHD without DCD (SDDMF). Antisocial personality disorder, alcohol abuse, criminal offending, reading disorders, and low educational level were overrepresented in the ADHD/DCD (SDDMF) group (58% vs 13% in the ADHD group without DCD [SDDMF]) (Fig. 1).

The comorbidity of DCD (SDDMF) and specific language impairment has been shown in up to 70% of the children with language problems.[79,95–97] Further, there are frequent comorbidities between DCD (SDDMF) and reading disorders and writing disorders.[82,88,98,99]

Coexisting learning difficulties has been interpreted as an indicator for severity and for perceptual–motor dysfunction.[100]

Montgomery et al.[98] point out that fluency and speed in writing are essential underpinning skills contributing to spelling accuracy and compositional ability in examination performance.

Children with developmental disorders often show neuropsychological deficits. Kastner and Petermann[101] looked for cognitive deficits in children with DCD (SDDMF). Children with DCD (SDDMF) scored below average in the Hamburg-Wechsler Intelligence test for children (Wechsler Intelligence Scale for children [IVth revision]) (verbal comprehension, perception reasoning, working memory, and processing speed). The general IQ scored one standard deviation below the comparison group. Other studies report less differences of total IQ.[38] Alloway et al.[102] also found selective deficits in visuospatial short-term and working memory in children with DCD (SDDMF). In the same study they found deficits in verbal short-term and working memory in children with language impairments.

ASD is also known to be associated with DCD (SDDMF).[97,103,104] In a population-based study, a comorbidity of ASD was found in 10 of 122 children with severe DCD (SDDMF) and in nine of 222 children with moderate DCD (SDDMF).[7]

Because of the comorbidities of DCD (SDDMF), ADHD, learning disorders, and autism, a common aetiology has been discussed.

An overrepresentation of DCD (SDDMF) in preterm and low-birthweight children (about 2:1) is known.[7,105]

In a recent genetic study in a large group of twins a consistent comorbidity was only confirmed in severe cases. In this twin

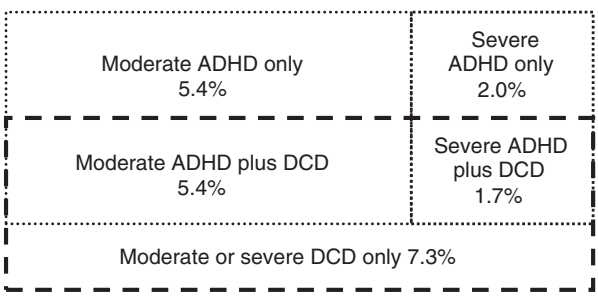


Figure 1: Overlapping of ADHD and DCD (according to Kadesjö and Gillberg[6]).

Table VI: Comorbidities of developmental coordination disorder (specific developmental disorder of motor functions) (DCD [SDDMF]) with learning and behavioural disorder: cluster analysis in a large twin study

Latent class[a]	Clinical feature	Frequency[a]	Percentage[a]
1	Unaffected	1957	62
2	Moderate inattentive–impulsive with ODD	440	14
3	Severe reading problems with moderate fine motor/handwriting	267	9
4	Control during movement with moderate gross motor planning	201	6
5	Inattentive–impulsive with reading problems, ODD, fine motor and general control	140	4
6	Inattentive–impulsive with ODD	114	4
7	Moderate to severe for combined ADHD, RD, ODD, and DCD scales with some CD	29	1
Total		3148	100

ODD, oppositional defiant disorder; ADHD, attention-deficit–hyperactivity disorder; RD, reading disorder; CD, conduct disorder.
[a]Frequencies and percentages for a 7 latent class solution concerning different patterns in symptomatology analysing 1304 families of twins (3148 individuals) from the Australian Twin ADHD Project.[106]

study, it could be shown that the motor symptoms of DCD (SDDMF) were in most children distinct from behavioural features like conduct disorder and ADHD. Only in severe cases was comorbidity common (latent classes 5–7, in Table VI). There was one cluster with children with severe reading disorders and fine motor functions and handwriting problems and one further cluster with movement control and gross motor planning.

In conclusion, despite numerous comorbidites in children with DCD (SDDMF) there is some evidence that DCD (SDDMF) exists as a distinct disorder at least as well as other ADHD, ASD, and developmental and learning disorders. DCD (SDDMF) seems to be critical for the outcome for example in ADHD and other socioemotional problems and it seems to predict success in some school abilities.

Statement 1 (++)

Because of the high probability of comorbidity in DCD (SDDMF), disorders like ADHD, ASD, and specific learning disorder, particularly specific language disorder and in later age reading problems (e.g. reading comprehension), have to be checked by careful history taking, clinical examination, and specific testing if possible, according to existing clinical practice guidelines.

If there is any hint for interference (e.g. attentional problems) with objective motor testing, the motor testing should be repeated, for example under medication or after other therapeutic intervention for attention problems.

8 SCREENING, ASSESSMENT

The requirement for objective reliable and norm-referenced tests in criterion I as recommended by the guideline group was the basis for the systematic search of the literature. A total of 34 studies and four (not systematic) reviews and overviews were found on this subject. Very recently, after the search period, a systematic review on measures of gross-motor function was published.[107] This was included in the evaluation. Further, a norm-referenced test or questionnaire to support criterion II may be useful.

Early identification of children with motor impairments has been recommended.[108,109] Instruments identifying motor impairments before the age of 5 are available and may be applied. However, screening instruments for this purpose are not sufficiently refined to enable highly valid and reliable assessment. On the other hand, the diagnosis DCD (SDDMF) before the age of 5 years is not generally recommended. This has already been discussed above (section 7.1.4).

8.1 Explanatory frameworks for different assessment approaches

According to the evaluative review by Wilson,[110] the following assessment approaches can be distinguished.

1. Normative functional skill approach. Assumptions about movement difficulties are largely process neutral. Approaches to assessment are descriptive, product-oriented (focus on functional skills), and norm-referenced. For example, the M-ABC is based on this approach.

2. General abilities approach. The guiding assumption here is that impaired sensorimotor integration underpins both perceptual–motor problems and learning difficulties. These impairments reflect neural damage. According to this approach, basic general abilities (like sensory–motor integration) can be measured, for example by the Sensory Integration and Praxis Test, and then should be a focus for treatment to improve motor functions.

3. Neurodevelopmental theory (biomedical model). Early neurological markers (e.g. clumsiness) predict disease states, for example 'minimal brain dysfunction'. This may be assessed by neurodevelopmental examination. An eclectic blend of neurological and learning tasks (e.g. soft signs or minor neurological dysfunction) will be tested. Normative data on soft signs are existing.[111–113] A new version of the Examination of the Child with Minor Neurological Dysfunction is available.[114] The manual contains criteria, cut-offs, and description of psychometric properties. Evidence is emerging that children with DCD often exhibit minor neurological dysfunction, in particular quite often the 'complex form of minor neurological dysfunction'.[115–117] This issue may deserve further attention. Advances in neuroimaging and functional imaging will provide insights into hard and soft signs of neural dysfunction. On the other hand, the role of minor brain dysfunction and minor neurological dysfunction for the development of a theory of DCD (SDDMF) has been questioned.[110]

4. Dynamical systems approach.[118] This approach suggests that the child with DCD (SDDMF) has had reduced opportunities to form movement synergies through interaction with learning tasks and environment. Assessments used within this framework include biomechanical, kinematic, and observational analyses.

5. Cognitive neuroscience approach. It is suggested that atypical brain development creates cognitive susceptibility. Reduced learning experiences exacerbate the risk for developing DCD (SDDMF). Approaches to assessment tend to be oriented towards brain systems that are of known importance to the development of movement skill (e.g. internal modelling or motor imagery, and timing control linked to parieto-cereballar loops; compare also section 7.2).

8.2 Questionnaires

Motor coordination test batteries are generally not feasible as screening protocols because of both time and costs. Researchers have argued for motor-based questionnaires that are completed by the child,[108,119] teachers,[120–122] and/or parents.[109] There are some parental and teacher questionnaires which were previously evaluated in the literature: the DCD-Q and its revised version (DCD-Q-R);[122,123] the M-ABC-2 and its revised version.[125,126]

The parental (DCD-Q) and the teacher questionnaire (M-ABC checklist) focus on ratings of ability and activity levels (self-care, ball skills, etc.).

There are other 'unspecific' scales and questionnaires that focus on activities. These instruments do not verify the diagnosis of DCD (SDDMF) but may be useful. Some examples are the Early Years Movement Skills Checklist;[127] and the Children Activity Scales for Parents and Children Activity Scales for Teachers.[128]

Furthermore, there are self-reports for children, most of which also assess aspects of self-efficacy for movement and self-esteem: the All about Me Scale;[129,130] the Perceived Efficacy and Goal Setting System;[49,129] and the Childrens Self-Perceptions of Adequacy in and Predilection for Physical Activity (CSAPPA).[108,119]

These instruments may provide an idea of how the child perceives their disorder, but self-reports are not confirmed to be specific and sensitive assessment tools for the diagnosis of DCD (SDDMF), although there are some encouraging recent studies (see, for example, concerning the CSAPPA[108,119]). There is a clear need for studies that evaluate whether these instruments are valid in the assessment of relevant aspects of DCD (SDDMF).

8.2.1 Evidence-based analysis of DCD (SDDMF) screening questionnaires

The results of the systematic review of DCD (SDDMF) screening questionnaires are shown in Table XI in Appendix I.

The guideline group agrees that a questionnaire may be useful as a first step diagnostic tool; however, the available instruments are not useful for population-based screening (owing to low sensitivity). It may be filled out by teachers or parents provided with sufficient instruction.

The DCD-Q-R (parent–report questionnaire) is so far the best evaluated questionnaire (four studies, levels 1b–3b according to Oxford classification for diagnostic studies). The DCD-Q-R is currently translated into German and studies on psychometric properties are underway.[123] Studies to support recommendation 9 are summarized in Table XI in Appendix I.

Parental information seems to be more valid than teacher information. The sensitivity and specificity are highly variable and depend on the sample (clinical or population based) and on who completed the questionnaire.

The CSAPPA has been examined mainly by one research group (four papers). Although it is generally recommended that the view of the child should be acknowledged, the CSAPPA questionnaire cannot be recommended because the instrument is not translated into German and is not validated in other European populations. Several terms in this scale are specific to North America; e.g. the different settings for participation.

The M-ABC checklist – revised is less well examined. For German-speaking countries there is no valid translation and there are no studies on psychometric properties yet. The sensitivity of the first version seems to be lower than that of the DCD-Q-R (five studies from 1997 to 2005, levels 1b–3b), although this depends on the chosen cut-offs. However, this may be different in the new M-ABC-2 checklist (not yet translated and validated in German).

In conclusion, further research is required to recommend questionnaires and self-reports for screening and examination of DCD (SDDMF). At present, questionnaires will at least help clinicians gain a more complete picture of the child's everyday activities and self-perception, particularly when used in centres with multidisciplinary settings.

The following recommendation is made:

Recommendation 9 (GCP++)

Concerning criterion II: it is recommended to use a validated questionnaire to collect information on the DCD (SDDMF)-related characteristics of the child from parents and teachers to support and operationalize criterion II.

Comment

At present, questionnaires may only be useful for clinical samples (see recommendations 11 and 12). However, there are currently no validated checklists or questionnaires for DCD (SDDMF) for German-speaking or other countries. Thus, the implementation of this recommendation depends on further research.

Recommendation 10

Concerning criterion II: questionnaires like the DCD-Q-R or the M-ABC2 checklist may be recommended for use in those countries where the questionnaire is culturally relevant and standardized.

Research note 1

A reliable method of operationalizing criterion II is urgently needed.

Recommendation 11

The use of questionnaires (e.g. DCD-Q, M-ABC checklist) is not recommended for population-based screening for DCD (level Aneg).

Comment

The guideline group does not recommend population-based screening for DCD (SDDMF); present studies of DCD (SDDMF) questionnaires suggest that the sensitivity is very low when applied in the general population (e.g. regular schools).[109]

8.3 Clinical assessment

8.3.1 History

History should include following aspects.

1. Parental report (GCP++)

- Family history including DCD (SDDMF), comorbidities, environmental factors (e.g. psychosocial factors), neurological disorders, medical diseases, mental disorders, social condition of the family.
  - Personal history including exploration of resources and possible aetiology (pregnancy, birth, milestones, achievements, social contacts, kindergarten, school [grades, levels]), previous and present disorders especially neurological disorders, sensory problems (previous assessments), accidents.
  - History of the disorder (child) including DCD (SDDMF) and comorbidities and exploration of resources, ADL and participation, individual/personal factors, burden of disease, consequences of the DCD (SDDMF).
  - Exploration of problems: present level/deficits of motor functions, ADL, and participation.[49,131]

2. Teacher report (GCP++)

- Motor functions, activities/participation, environmental factors/support systems, individual/personal factors (ICF).
  - School-based behaviour that bears on comorbidity for attentional disorders, autistic spectrum, specific learning disorders.
  - Academic achievement.

3. Views of the child

These should be taken into account (GCP++); child-adapted questionnaires (see above) may be useful, but cannot be generally recommended (GCP++).

Recommendation 12 (GCP++)

Concerning criteria I, II, III: careful history taking is essential to support the application of criteria I, II, III.

8.3.2 Clinical examination

The clinical examination is necessary to exclude the presence of other medical conditions that may explain motor impairment. The aim of the neurological status is to rule out other movement disorders and to support criterion III. A comprehensive clinical examination should be performed to verify that the disturbance is not due to a general medical and/or psychosocial condition (e.g. cerebral palsy, hemiplegia, or muscular dystrophy, deprivation or child abuse).

- Exclusion of neurological disorders such as of corticospinal, cerebellar, extrapyramidal, or neuromuscular origin. Signs of neurometabolic disorders or of acquired neurological disorders (pre-, peri-, postnatal), peripheral neurological disorders.
- Minor neurological dysfunction. There are few studies on 'minor neurological dysfunction' or on 'neurological soft signs' (e.g. associated movements, mirror movements). Normative data on soft signs can be found in Largo et al.[111,112] However, motor skills and speed only correlate weakly with soft signs: around 0.2 according to Gasser et al.;[113] no significant correlation are found between soft signs and M-ABC scores in Volman et al.[42] Thus, there is currently no reliable evidence for diagnosing DCD (SDDMF) through the examination of soft signs. Neurological soft signs are not indicative or sufficient for the diagnosis of DCD (SDDMF). However, two Scandinavian studies[132,133] and older studies by Gillberg et al.[134–136] provide some data to support reliability and some aspects of the validity in the assessment of neurological soft signs in children with ADHD and motor impairments. Thus, there may be some support for the clinical use of soft signs in specific cases (e.g. children with severe attentional problems who may otherwise not be tested reliably). Recent studies indicated that neurological condition in terms of the severity of 'minor neurological dysfunction'[115–117] improve the insight into the child's neurological condition which in turn facilitates the understanding of the child's strength and weaknesses to organize motor skills. These studies emphasize that the assessment of minor neurological dysfunction is not meant to diagnose DCD.
- A behavioural and cognitive evaluation is recommended for all children with DCD (SDDMF) because attentional disorders, learning disorders, and ASDs are frequent comorbidities. If there are signs of behavioural or emotional problems, further examination according to the respective guidelines is necessary.
- Cognitive function does not need to be evaluated by objective measures (e.g. IQ testing) if there is a normal history of school and academic achievements. However, a test for intellectual ability is recommended, if there is any doubt.

Recommendation 13 (GCP++)

Concerning criterion III: appropriate clinical examination with respect to medical, neurological, and behavioural problems is necessary to verify that the disturbance is not due to a general medical, neurological, or behavioural condition.

Statement 2 (++)

The clinical examination should include neuromotor status (exclusion of other movement disorders or neurological dysfunctions); medical status (e.g. obesity, hypothyreosis, genetic syndromes, etc.); sensory status (e.g. vision, vestibular function); emotional and behavioural status (e.g. attention, autistic behaviour, self-esteem); cognitive function should there be a history of general learning difficulties at school.

8.4 Assessment with standardized tests

According to the recommendations on definition of DCD (SDDMF) in section 7.1.4, an appropriate, valid, reliable, and standardized motor test (norm-referenced) *should* be used.

There are numerous tests on motor functions but only a few tests have been designed and tested for the assessment of the diagnosis DCD (SDDMF).

8.4.1 Assessments on motor functions according to criterion I

In addition to the clinical examination, which is more focused on the level of body structure and functions (according to the ICF), assessment using one of the following standardized tests is more focused on the level of activities.

Within the literature search interval from 1995 to 2010 (January), 19 studies examining the M-ABC were found. Five studies examined the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), three studies (including one from 2010) on the Körperkoordinationstest for Children, and three on the Zurich Neuromotor Assessment Battery (ZNA). The last two tests have not been validated for the specific diagnosis of DCD (SDDMF). The McCarron Assessment of Neuromuscular Dysfunction has also been used in several studies of DCD (SDDMF) and has shown good convergent validity (see, for example, Brantner et al.[137]).

A recent systematic review on assessment instruments in gross motor functions[107] came to a similar conclusion. In this publication, seven measures of gross-motor function met the inclusion criteria and were appraised for their psychometric properties. The M-ABC scored highest and was recommended in the first instance for clinicians wishing to evaluate gross motor performance in children with DCD (SDDMF).

8.4.1.1 M-ABC, M-ABC-2 The M-ABC[125,126] is by far the test most commonly used and best examined (see Tables XII and XIII in Appendix I).

The M-ABC-2 is a norm-referenced test for children from 3 years 0 months until 16 years 11 months split in three age groups (M-ABC [first version] 4 until 12+ years, split in 4 age groups); compared with the older version of the M-ABC it has different combinations of test items in each group. In some countries (including Germany), norm values are only available for a limited age range (4y 0mo to 10y 11mo). Numerous studies on the M-ABC were not primarily designed to examine test criteria, but factors that influence the test criteria. Thus, only studies with representative samples and a sound methodological background were included in the evaluation. In addition, the study samples used within the English, Dutch, and German test manuals were taken into account.

8.4.1.1.1 Psychometric properties of the M-ABC The studies on the M-ABC show good to excellent interrater reliability, good to excellent test–retest reliability and fair to good validity (construct validity and concurrent validity with BOTMP). The specificity seems to be good and the sensitivity fair to good in comparison with the BOTMP depending on the chosen cut-off (good sensitivity using the cut-off 15th centile).

8.4.1.1.2 Limitations of the M-ABC There is a lack of research on the discriminant validity of the M-ABC. We note that attentional problems may interfere significantly with performance on the M-ABC. Furthermore, there seems to be a training effect of the M-ABC if repeated within 4 weeks, although this effect seems to be less in children with severe DCD (SDDMF).

A further problem may be the scaling of the reference values (e.g. with 'floor effects' in age band 1 [3–6y]). The 'discontinuation' of the scales moving from one age band to another may be a problem in longitudinal comparisons, when children, for example, move from kindergarten to school age and for the comparison of children in first grade (6- to 7-year-olds). These age ranges are often critical for DCD (SDDMF) diagnosis and treatment monitoring. Moreover, the age norms are fairly broad (German version: half-year interval only in 3- to 4-year-old children, year intervals in all other children). No sex effects have been found. This finding is in contrast with the findings of the BOTMP, second version (see section 8.4.1.2).

8.4.1.1.3 Comments on the M-ABC second version According to a consensus of international experts (EACD consensus conference in Brussels 2010) in collaboration with the guideline group, most validity measures from the M-ABC may be valid for the M-ABC-2 version as the construct has remained the same. Furthermore, it was assumed by the experts that it would be very unlikely that the test criteria were very different between European countries as motor function itself would not be strongly influenced by subtle cultural variations. Nevertheless, Chow et al.[138] comparing Chinese children with American children found some cross-cultural differences. Also, the Dutch norms suggest differences.[139]

Taking into account the strengths and limitations of the M-ABC, the level of evidence on quality and suitability of the M-ABC(-2) for the diagnosis of DCD (SDDMF) is rated as moderate to good. Using strict criteria for test quality, the level of evidence from the literature concerning all test criteria and measurement properties cannot be level 1 at present.

8.4.1.2 BTMP, BOTMP-2 The BOTMP is a norm-referenced test of motor function, mainly used in the USA and Canada. The BOTMP provides a general motor ability factor. It is divided into eight subsections, including the ability to run and general agility, how well the child can maintain balance, and coordination of bilateral movements. It is also used to assess quality of movement, coordination, speed and dexterity of upper limbs, the speed of response, and visual motor control. The recent second version of the BOTMP (BOTMP-2) provides norms from 4 to 21 years. The age norms have 4-month intervals in preschool children, half-year intervals in school children and 1-year intervals in adolescents above 14 years. The instrument has separate norms for each sex.

8.4.1.2.1 Psychometric properties of the BOTMP and BOTMP-2 The BOTMP/BOTMP-2 shows good to excellent reliability, fairly good validity (construct and concurrent valid-

ity with M-ABC-2), good specificity, but lower sensitivity than the M-ABC. Primary strengths of the BOTMP-2 include that (1) the administration contains photos which help to minimize language demands and provides cues for examiners that support standard and efficient test administration; (2) the face validity of the items reflect typical childhood motor activities (e.g. ball skills, movement, paper/pencil activities, card sorting); (3) the construct validation of the test is good; (4) the moderate to strong interrater and test–retest reliabilities for both the Total Motor Composite and the Short Form; and (5) the fact that the norms are relatively up-to-date and reflect the demographics of the USA.[140]

8.4.1.2.2 Limitations of the BOTMP/BOTMP-2 Limitations include (1) weak test–retest reliabilities for some subtests and motor area composites for some age groups which limit confidence in the use of these scores; (2) the scoring process which is time-intensive and tedious with errors likely to occur due to the multiple step process and the characteristics of the Record Form and Norm Tables; and (3) the difficulty of the items for 4-year-old children who are typically developing or 5-year-old children with delays;[140] (4) norms for the German-speaking countries are lacking.

In sum, the level of evidence for the quality and suitability of the BOTMP is rated as moderate (LOE 2), but in general the evidence is weaker than for the M-ABC particularly concerning the sensitivity of the test. However, the original American standardization population is large and the reference values with a 4-month interval in young children seems to be convincing. There is only an English version with US norms (no German version).

8.4.1.3 McCarron Assessment of Neuromuscular Dysfunction The McCarron Assessment of Neuromuscular Dysfunction has mainly been used in Australia (two studies) and is not further discussed (LOE 3).[137]

8.4.1.4 Other tests Several other tests that assess motor functions are found in the literature, but they have not been evaluated with respect to the diagnosis of DCD (SDDMF) (level 0, LOE 4) for making the diagnosis DCD [SDDMF]). In most studies, there are one to three published papers on test criteria (LOE 2–3). They may be suitable for testing motor abilities.

Examples are the following:

1. The ZNA examines motor abilities (e.g. finger tapping), motor skills (static balance, pegboard, rope jumping) and associated movements (movement quality, soft signs) in 5- to 18-year-old Swiss children and adolescents. Several studies have been published assessing the test–retest, interobserver, and intraobserver reliability,[141] construct validity,[142] and the validity of the ZNA in children born preterm.[143,144] Studies also presented age-related normative values (centiles)[111,112,145] and examined the influence of age, sex, and left-handedness on the motor tasks.[113,145] However, no study has yet assessed concurrent validity of the ZNA with the M-ABC and its usefulness for diagnosis of DCD (SDDMF). The ZNA is one of the most common used motor tests in Switzerland.

2. Körperkoordinationstest für Kinder has undergone a recent revision. Test criteria, however, are only examined to some extent.[146] The most important requirement for test procedures is the need of actual norms.[147] Despite a revision of the test manual in 2007, no new norms were created. The current norms are still from 1973 and 1974. The authors believe that a new standardization is not necessary because children may still have comparable motor performance.[148,149] Several studies have shown, however, that there has been an alarming downward trend in motor ability over the past 40 years. The average motor quotient of the Körperkoordinationstest für Kinder has been consistently lower in all recent studies (MQ89 [Otten et al.[150]] and MQ89 [Prätorius et al.[151]] vs MQ100 of the original version). Furthermore, the standardization procedure from 1973/1974 is unclear. Bös[152] has expressed doubts on the exclusive measurement of coordinative performance by the Körperkoordinationstest für Kinder. Some subtests require more performance on force and endurance.

3. MOT 4-6 is a test of fine and gross motor functions designed for children between 4 and 6 years that was developed in the 1980s. A recent study from 2003 has shown that the norms from the 1980s may still be valid. In contrast to schoolchildren, normative data for young children and preschoolers had not changed appreciably between 1987 and 2000 (Rethorst[153]).

4. Peabody Developmental Motor Scales is a quantitative and qualitative assessment of gross- and fine-motor development in young children (birth to 5y). It is based on an age-stratified sample of 2000 children. It may be useful for descriptive and evaluative use in young children below 4 years.

5. Bayley Scales of Infant Development III is a comprehensive developmental test, evaluating motor, language and cognitive functions in infants and toddlers, age 0 to 3 years. The motor subscale may be useful for descriptive and evaluative purposes in assessing early motor dysfunctions within the general developmental assessment.

6. Frostig/FEW2 (DTVP2) may be useful for diagnosing visual–motor/visual perceptive problems.

7. Handwriting fluency test for older children (e.g. Detailed Assessment of Speed of Handwriting[154,155] [UK norms]) may be useful for diagnosing a writing disorder (not available in Germany).

8. Systematische Opsporing van Schrijfproblemen/Beknopte Beoordelingsmethode voor Kinder Handschriften[156–159] (Dutch norms, French norms) (Concise Assessment Methods of Children Handwriting[156]) is a tool designed to screen poor handwriting quality on the basis of a completed piece of cursive writing for children in elementary school. The writing task consists of copying a standard text in 5 minutes or at least five lines if the child is a very slow writer. The text is copied on unruled paper. The test offers 13 criteria to evaluate the quality of the handwriting product. The test also evaluates speed of writing. The interrater agreement between pairs of raters has been reported to vary between r=0.71 and 0.89, with a median of r=0.82. Furthermore, the correlation between the Beknopte Beoordelingsmethode voor Kinder Handschriften (Dutch

handwriting observation and analysis method for children's writing) and the Dysgraphia Scale is reported to be 0.78 (Hamstra-Bletz and Blöte[159]). The scoring of the test needs extensive training and takes about 15 minutes if the tester is trained. Therefore, the test is not useful as a screening instrument.

For the Systematische Opsporing van Schrijfproblemen (systematic screening of handwriting problems), the most discriminating items were selected from the Beknopte Beoordelingsmethode voor Kinder Handschriften, reformulated and concretized to develop the Systematische Opsporing van Schrijfproblemen test.[160] The Systematische Opsporing van Schrijfproblemen consists of six well-described criteria used to evaluate the quality of the handwriting screening. The child has to copy a text in 5 minutes. Writing speed is measured by counting the number of letters.[161] Criterion validity with the Beknopte Beoordelingsmethode voor Kinder Handschriften is good (r=0.80–0.88, p=0.01).[160,162]

9. Other useful instruments for the diagnosis of a handwriting disorder include the following: Minnesota Handwriting Test, the test on Diagnosis and Remediation of Handwriting Problems, Children's Handwriting Evaluation Scale-Manuscript, Evaluation Tool of Children's Handwriting–Manuscript, and Test of Legible Handwriting (not available in Germany).

10. Purdue Pegboard Test (French norms, no German norms) is a test for dexterity and fine motor performance.

With respect to DCD (SDDMF), no peer-reviewed articles on the psychometrics and standardization (German-speaking countries/European countries) of the following tests have been found: Münchner Funktionelle Entwicklungsdiagnostik (Munich Functional Development Assessment); Ruf–Bächtiger-Test; Sensory Integration and Praxis Test.

Based on the literature search, the following recommendations can be made.

Recommendation 14 (GCP++)

Concerning criterion I: An appropriate, valid, reliable and standardized motor test (appropriately norm-referenced) should be used.

Comment concerning criterion I

Evidence from a standardized norm-referenced test is necessary to establish that motor performance is substantially 'below expected levels'. Ideally, the evidence is derived from a test with culturally relevant developmental norms. Otherwise, this criterion cannot be reliably met. The diagnosis of DCD (SDDMF), however, should *not* be made only on the basis of a standardized motor test. It requires careful history taking, clinical examination and confirmation using valid tests and questionnaires (see sections 8.2 and 8.4).

Recommendation 15

Concerning criterion I: in the absence of a criterion-standard test for establishing criterion I, the M-ABC-2 may be recommended (LOE 2, level B). Where available, the BOTMP-2 may also be recommended (LOE 2, level B). However, no German translation and standardization of the BOTMP-2 is currently available.

In the absence of generally accepted cut-offs for identifying DCD (SDDMF), it is recommended that when using the M-ABC, or other equivalent objective measures, approximately the 15th centile for the total score (standard score 7 or less) should be used as a cut-off.

Comments

Concerning the use of the M-ABC-2 with German and Swiss children, the applicability of the Dutch norms with the Dutch standardization studies may also be considered until further research has been done on the M-ABC-2 in Germany.

In a comprehensive review, a distinction between clinical diagnostic criteria and research criteria was postulated.[163] The guideline group also emphasizes that the purpose for clinicians and researchers may be different. For clinicians, it is important not to miss children in need of adequate support. Limited sensitivity of the present motor test battery and specific deficits relevant for daily activities in certain areas (e.g. balance or dexterity) would mean that many children with moderate DCD (SDDMF) would be missed if using the 5th centile. Several studies examining the sensitivity and specificity of the M-ABC compared with other measures also used the 15th centile. They found reasonably good agreement between measures when using the 15th centile.[164–168] This view is also supported when population-based data are analysed.[7,8] It is therefore plausible to use a cut-off level of 15th centile in addition to criteria II and III.

The MOT4-6 may be considered for 4- to 6-year-old children and the ZNA for children of all age groups in German-speaking countries. However, these tests are not yet validated for the diagnosis of DCD (SDDMF).

Recommendation 16 (GCP++)

Based on the limitations of the available instruments, classification of specific domains of dysfunction (e.g. gross motor or fine motor dysfunction [ICD F82.0 and F82.1]) can be made on the basis of clinical judgement.

The use of gross motor or fine motor items of standardized assessments may be recommended alongside observation and reports of difficulties across relevant gross motor or fine motor and/or graphomotor tasks.

The guideline group suggests the fifth centile cut-off of the fine motor subdimension (e.g. M-ABC-2, BOTMP-2) be used for the diagnosis F82.1 if criteria II and III are met.

If all criteria I, II, and III are met, and if fine motor function is within the normal range, then the diagnosis F82.0 can be made.

Comments

It should be noted that the clinical relevance of subscales (M-ABC-2, BOTMP-2, and other tests) is not yet established by systematic research. Accordingly, the diagnosis of a graphomotor disorder cannot be made on the basis of the M-ABC-2 and other motor tests alone. Where available, tests with country-specific standardization may be recommended (e.g. for handwriting, Detailed Assessment of Speed of Handwriting, Beknopte Beoordelingsmethode voor Kinder Handschriften/Systematische Opsporing van Schrijfproblemen).

If a child shows particular difficulties on one domain (i.e. performs below the fifth centile), but performs above the 15th centile on other domains, the child should be considered to have a domain specific DCD (SDDMF) (e.g. fine motor, gross motor). If uncertain, repeated testing or an additional motor test may be used to support the diagnosis.

Recommendation 17 (GCP++)
Concerning criterion I: for children between the ages of 3 and 5 years, if the diagnosis is needed (e.g. for treatment purposes), a cut-off of no more than the fifth centile is recommended for the total score on the M-ABC, or equivalent objective measures (see also recommendation 8).

Research note 2
Given the weaknesses of the M-ABC-2, the BOTMP-2, and other tests, the following aspects need to be addressed in future research.

- Discontinuity particularly between age bands in the M-ABC-2 (specifically when transferring from age band 1 to age band 2) and therefore problems with longitudinal measurements (when becoming 7y of age).
- Need for reliability testing within each age band (e.g. M-ABC-2, BOTMP-2).
- Possible floor effects* of the M-ABC-2 (particularly in age band 1 should be further examined).
- The role of motor capacity measures (e.g. maximum grip force, maximum tapping frequency) in DCD (SDDMF) has to be further examined (e.g. the BOTMP-2 and the ZNA include motor capacity items whereas the M-ABC-2 test is mainly restricted to motor coordination and dexterity items).
- Further data on discriminative validity (e.g. sensitivity and specificity) are needed.
- Norm-referenced and valid subtests (e.g. dimensions of the M-ABC-2 or BOTMP-2) for the DCD (SDDMF) subgroups with predominant fine motor or gross motor problems are needed.
- For German-speaking countries, there is a need for a norm-referenced, valid test for handwriting.

8.5 Treatment indication and treatment planning
Children with DCD (SDDMF) fulfilling diagnostic criteria I, II and III usually need treatment. However, in some cases diagnosis does not indicate treatment. Therefore, the guideline group decided to give additional recommendations on treatment indication.

On the other hand, if the test criteria for the diagnosis of DCD (SDDMF) are not met but problems exist in the performance of everyday living tasks, educational and social support strategies for participation across environmental contexts should be implemented. This may be particularly useful for children below the age of 5 years showing significant motor impairments without meeting the diagnostic criteria of DCD (SDDMF).

Recommendation 18 (GCP++)
In determining if treatment is indicated, an account of personal factors, environmental factors, burden of disease and participation should be taken into consideration.

Sources of information include history (including previous diagnostic and therapeutic history), clinical examination, parental report, and, if possible self-report, teacher or kindergarten reports, questionnaire information, and motor test results.

Recommendation 19 (GCP++)
If treatment is indicated, information on personal factors, environmental factors and the burden of disease concerning participation should be used for planning the treatment.

Statement 3 (++)
In addition, when planning treatment, evidence of treatment efficacy including regime and/or dose should be considered. As children may have coexisting disorders, for example ADHD, treatment priorities need to be established. Individual factors, for example motivation or psychosocial factors (e.g. broken-home, parents with psychiatric disorders) may strongly limit the efficacy of motor treatment or treatment may not be possible at all. On the other hand, in some children with DCD (SDDMF) compensatory and environmental support may be sufficient.

The severity of motor impairment impacts not only the presentation of DCD (SDDMF) but also participation, which has important implications for treatment.

In schoolchildren, specific fine motor problems may be more relevant for school achievement than gross motor problems. Gross motor problems seem to be important for participation and development of social contact with peers.

Recommendation 20 (GCP++)
For treatment planning, individual goal setting should be used. Goals set at the level of activities and participation should be given priority and the child's and family's viewpoint should be taken into account.

Comment
Individual goal setting using specific tasks according to criterion II is urgently needed. This recommendation has also to be seen in combination with recommendation 24 (section 9.2.1). Although goals at the level of body functions may also be defined, the main goals should be set at the level of activities and participation. Appropriate tools for goal setting on the level of participation include the Canadian Occupational Performance Measure[169] or the Goal Attainment Scaling.[170]

Research note 3
The role of 'goal setting' with respect to treatment regime and/or dose and the outcome of DCD (SDDMF) needs to be further examined.

*Analogous to the ceiling effect, the floor effect means that in six out of 10 tasks in age band 1 the scoring values start with standard values above five points. Lower values are not possible because of the construction of the test items. Thus, measurement the precision of the measurement at the lower end is rather limited in children in age band 1. Only the dexterity tasks show sufficient scaling (German standardization).

Recommendation 21 (GCP++)
To evaluate treatment effects, measures that capture the level of activities and participation should be used.

Sources of evaluation are clinical examination, parent report, teacher/kindergarten reports, questionnaire information, motor test results, and child's view.

Recommendation 22 (GCP++)
If testing is performed during the intervention period, it should inform adjustments to treatment through adaptation of individual goal setting.

Comment
The M-ABC may be useful for therapy evaluation. However, attention should be paid to possible repeated testing effects (e.g. intervals less than 3mo). The M-ABC can be used for evaluation of intervention over longer periods (e.g. 3mo or more).[28]

Research note 4
Retest effects of multiple testing with standardized motor tests over short and long periods should be further investigated.

9 TREATMENT

9.1 Therapeutic approaches

Interventions for children with DCD (SDDMF) found in the literature are therapeutic approaches in occupational therapy and physiotherapy, supplementation and other treatment methods (section 9.1.2), and educational approaches (teachers, parents, physical education). In this guideline therapeutic approaches in occupational therapy and physiotherapy and supplementation/medication are discussed.

9.1.1 Therapeutic approaches: occupational therapy, physiotherapy

Three main professions provide treatment for children with DCD (SDDMF): occupational therapy, physical therapy, and special education. In a few cases medical/dietary therapeutic approaches have been studied. Educational approaches are not discussed in this clinical practice guideline.

Occupational therapy offers children and adults methods to improve performance of everyday activities and participation in situations that are meaningful and important to them. Occupational therapists analyse capacities and performance and develop intervention and therapy solutions for problems around performance and participation together with their clients, in this case children and families. They use different approaches depending on child and family, goals and situation, for example process-oriented approaches like sensory integration therapy, strategic task-oriented approaches like Cognitive-Orientation to Occupational Performance (CO-OP), adaptation of environment, and, in some countries, also therapy in group settings. They use standardized assessments to evaluate the children's performance, body functions, and needs (see Tables XI–XIII in Appendix I). Great emphasis is given in occupational therapy to analysing and adapting the material environment and in counselling and coaching the parents and class teachers. In addition to improved functional ability and participation, quality of life and life satisfaction are important goals of occupational therapy.[171]

Physical therapy enables children and adults to develop and optimize their mobility and movement-related functions. The purpose of the physiotherapy treatment is to achieve meaningful participation in areas of life as independently and unaided as possible and with high quality of life. Treatment priorities are based upon information from the child, parent, and school, as well as the professional knowledge of the therapist about motor learning, motor control, and constraints related to the disease and age. The hypothesis-oriented algorithm for clinicians II (HOAC II) is commonly used to guide clinicians when documenting patient care and incorporating evidence into practice.[172] It helps to justify interventions for problems that require remediation and those that may occur in the future and that require prevention. Physical therapists are specialized in analysing motor development, movements, and specific activities as well as in determining relevant problems in cases of dysfunctions. Together with the social system of the client, goals will be arranged to cope with the problems. Physical therapists use different approaches depending on child, and family, goal and situation, for example process-oriented approaches like adapted neurodevelopmental therapy, sensory integration, strategic task-oriented approaches like CO-OP, or specific task-oriented interventions like neuromotor task training (NTT) and adaptation of environment. They use tests like M-ABC-2 or BOTMP in their assessments and parent/teacher questionnaires to evaluate the motor development and performance of the children and their needs. Counselling and coaching the parents and class teachers are important in physical therapy.

9.1.2 Supplements and medication

Supplements and medication are often used in children with comorbidities, for example ADHD. They are based on biological and neurological knowledge, for example that fatty acids are needed in the development of the nervous system or that methylphenidate (MPH) reduces difficulties in attention.

9.1.3 Search results for terms and labels of intervention

Regarding the different interventions studied for efficacy, various labels were found in the literature. Moreover, owing to word restrictions of most journals, description of the intervention undertaken is often very limited.

In our literature search we found the following approaches and terms for intervention: perceptual motor therapy (PMT); sensory integration therapy (SIT); CO-OP; NTT; contemporary treatment approach or traditional approach; individual tutoring; motor imagery; weight bearing exercises; writing exercises; parent-assisted motor skills; movement-quality (effort) training; individual and group programmes; psychomotor training; le bon départ; guided parent or teacher intervention; kinaesthetic training; specific skills training.

From this list, some approaches are rather similar, for example the contemporary treatment approach, traditional

approach and PMT; some are only exercises, for example weight-bearing exercises, writing exercises, movement-quality (effort) training or teaching methods like individual tutoring; others are only mentioned in older studies like kinaesthetic training; many of them are only known in the country where they were developed or are only the subject of one study; although some of the approaches have been developed in a specific profession (e.g. SIT and CO-OP in occupational therapy, NTT in physiotherapy), the use of an approach is not limited to a profession: it is more dependent on the specifics of a health system, which can vary considerably in different countries.

In the following text and in the recommendations, approaches or exercises without evidence or current literature are left out. Based on the theoretical background and the intervention approach, two main groups of approaches were differentiated: top-down and task oriented; bottom-up and process-oriented (also called deficit-oriented).

9.1.4 Theoretical background

As described in section 7.2, there are different theories to explain the underlying mechanism of DCD (SDDMF). Different treatment approaches are derived from these theories depending on the time when the approaches were developed.

Earlier theories propose a rather strict hierarchy of motor control where higher centres of the nervous system plan the movements, followed by execution of the movements by the lower centres. These theories are often based on neurodevelopmental theory. More recent theories include the dynamical systems model[118] and the neural group selection theory.[173–175] The dynamical systems theory describes motor control and motor development as the result of more complex interactions between various levels of the nervous system, where feedback is interpreted by the nervous system and appropriate movement strategies arise from an interaction between task, person, and environment, involving extrinsic and intrinsic constraints.[174–176]

The neural group selection theory includes aspects of developmental neurobiology, and dynamical system theory and proposes functional groups of neurons at all levels of the nervous system, although their functional integrity depends on afferent information, which is produced by movement and experience.[173,176] Cognitive, behavioural, and learning theories are also integrated into intervention methods.

9.1.5 Intervention process and orientation

The process-oriented approach in the context of intervention means that the treatment addresses components or body functions needed to perform activities. In the case of DCD (SDDMF), the hypothesis is that the improvement of body functions like perception, sensory integration, muscle strength, visual–motor perception, etc. leads to better skill performance.

Bottom-up or process-oriented approaches are, for example, SIT, kinaesthetic training, PMT, or combinations.

SIT was developed in 1970s in the USA by the occupational therapist Jean Ayres.[177] The therapy provides sensory stimulation to promote motor development and higher cortical learning.[176] It is still a popular method used by occupational therapists.[174,175] The intervention expects to help children through providing proprioceptive, tactile/kinaesthetic, and vestibular stimulation aimed at remediating the proposed underlying sensory deficit.

Kinaesthetic training was described by Laszlo and Bairstow.[178,179] Critical appraisals are made by Sims and colleagues.[180,181] Kinaesthesia is an important factor in motor control and learning of movements. It has been suggested that a child with motor difficulties is deficient in kinaesthetic perception and that remediation of these kinaesthetic difficulties will carry over and improve the overall motor performance.[174,175]

PMT is based on the idea that perceptual qualities and motor abilities are functionally linked.[182] It promotes learning through positive feedback and reinforcement.[176]

In contrast to bottom-up approaches like process-oriented approaches, task-oriented approaches can be seen as top-down approaches. 'Top-down' in this context means that the performance of the child in certain activities is analysed to identify factors in the behaviour and the context that influence the performance. Then strategies are developed for a better interaction between child, task, and environment. Body functions or underlying processes are also factors but only if they are connected to the wanted activity or participation. Therefore, we use the term 'task-oriented' instead of 'top-down'.

Task-oriented approaches are influenced by the dynamical systems and the neural group selection theory and include functional, task-specific, and cognitive approaches. Task-specific approaches focus directly on functional skills.[100] A specific task is broken into steps that can be practised independently and linked together to accomplish the entire task.[175] Therefore techniques from behavioural theory such as chaining or cognitive strategies from cognitive theory can be used.[183,184] For active problem solving a cognitive approach is used.[174] Task-oriented approaches are CO-OP, motor imagery training, and NTT.

CO-OP was developed by Helene Polatajko and Angela Mandich in Canada from the end of the 1990s. It focuses on performance of the activities that a child needs or wants to master. CO-OP improves knowledge of the task, cognitive strategy use, learning and teaching principles, self-instruction, adaption of environment and involves the Goal-Plan-Do-Check framework.[176] It is based on the belief that when a child guides himself through a problem-solving task by talking aloud, he learns to regulate his behaviour by learning how to identify a goal, develop a plan and evaluate the success of that plan.[185] Through such aspects as parent training and homework, the ability of problem-solving and skill acquisition is transferred to daily life.

NTT was developed in the Netherlands.[164] It is a task-oriented training programme for children with DCD (SDDMF) originally developed to be used by physical therapists. Skills are taught through task analysis, which breaks down a task into its component parts and will enable focus on the main problems

in the task. Task analysis encompasses planning (what needs the child to know about the task), execution (what the child has to be able to 'do' to perform the task), and evaluation (what sorts of feedback are available), to be able to adapt the task to make it feasible for the child to learn. Depending on the learning stage a child has reached for a particular skill, skills are learned progressively through task loading, changing spatial and temporal constraints of the task, and by combining tasks. In this methodology, task or environmental constraints are changed to make a task more difficult (or easier), which makes the approach also suitable for younger children or children who are verbally less competent. In addition, knowledge from studies on motor learning strategies about the most effective method to instruct, practice and provide feedback are implemented in the treatment sessions, taking into account the level of proficiency. If a child still needs to know how to solve a task, cognitive strategies can be used or giving a good example if necessary. Once the child has a notion how to do the task, variable training is given (by changing materials, environment, and rules). In this phase a lot of practice time (time on task) is provided (partly through homework).

Motor imagery training was developed by Wilson[110] in Australia. It uses internally modelling of movements which facilitates the child to predict consequences for actions in absence of the overt movement. In time and with practice, children use the knowledge of the relation between vision and kinaesthesis to make appropriate predictions about the consequences of self-produced movements, which will reduce the errors in feedforward planning.

9.1.6 Environmental factors

The importance of the contextual factors as described in the ICF is taken into account in all the mentioned approaches. Adapting tasks, environment, as well as educating parents and significant other persons like teachers are important parts of most of the interventions (see section 9.2.1).

As described in section 7.6, comorbidities like Asperger syndrome, ADHD (hyper- or hypoactivity), or specific learning disorders and perception disorders are often seen in children with DCD (SDDMF). Perception disorders, for example, can be visual or visuo-motor integration problems. Interventions should address the motor problems as well as the other difficulties. Therapists have to decide which methods are appropriate. Priorities for treatment goals and approaches have to be considered within the medical team and with child and family (see section 8.5).

9.2 Recommendations and statements

*9.2.1 General recommendations**

In a systematic review of interventions on DCD (SDDMF), Hillier[186] generally concluded that an intervention for DCD (SDDMF) is better than no intervention. However, a certain bias for the reporting of positive results may have to be taken into account.

Independently, the guideline group has performed a systematic literature search of studies published from 1995 to 2010 (see Table XIV in Appendix I).

There is sufficient evidence that physiotherapy and/or occupational therapy intervention is better than no intervention for children with DCD (SDDMF).[100,180,187–193]

Recommendation 23

Children with the diagnosis DCD (SDDMF) should receive intervention (LOE 1, level A).

This means that if specific recommended approaches are not accessible or applicable (cognitive status, cooperation, age) other approaches may be indicated instead of leaving the child completely untreated.

In their meta-analysis of intervention approaches, Pless and Carlsson[194] reported the highest effect size for this group of task-oriented approaches. Task-oriented approaches work on teaching essential activities of daily living and thereby stimulate participation in the child at home, school, leisure, and sports.[176,189,192,195–200] It is shown that task-oriented approaches are effective in treating children with DCD (SDDMF).[194]

Looking at more recent studies and those with higher-quality, task-oriented approaches to improve motor tasks or selected activities based on goal-setting seem to be more successful than process-oriented approaches. The effect sizes against comparisons are consistently larger than those found in process-oriented approaches.

Individual or group programmes are both effective ways of teaching task-oriented approaches. Although the meta-analysis from Pless and Carlsson[194] has methodological limitations, the results should be taken into account. They reported the highest effect size for task-oriented approaches. Task-oriented approaches work on teaching essential activities of daily living and thereby stimulate participation in the child at home, school, leisure, and sports.[174,176,188,189,193,196] Task-oriented approaches should also be used to improve motor performance when treating children with DCD (SDDMF).[194]

Task-oriented approaches using a cognitive approach demand certain requirements from children. They must be able to set goals for themselves, have enough cognitive abilities to benefit from this approach, and, because this approach is based on therapist/client verbal interaction, sufficient language skills are necessary. Also, the children need a level of approachability to react and respond to the intervention. Therapists therefore have to adapt their approach.[201] This may require that in some groups of children other approaches also have to be used. General abilities approaches may be recommended to improve motor tasks or selected activities based on goal-setting if task-oriented approaches are not available or feasible (e.g. because of low IQ or age).

Applying different approaches may be indicated as in children with developmental disorders there is often an overlap between DCD (SDDMF), attention deficits and learning disorders. Children with additional language difficulties may

*Concerning the recommendations on CO-OP and NTT, the representatives of these methods have not been included in voting for recommendations on these methods.

also require occupational therapy treatment. No specific studies, however, have been found that evaluated differential treatment effects in groups of children with various comorbidities.

Taking into account the huge body of evidence from the literature for effector-specific motor learning, and because this notion has been translated to clinical practice by task-oriented approaches, it seems to be justified to recommend direct task training such as handwriting or activities of daily living and their specific components.[202] Shumway-Cook and Woollacott[202] conclude in their book on motor control that many studies have supported the hypothesis that practice of the task to be learned or relearned will result in most gains (p538). Such task-specific training must be age-appropriate to enhance success (p539). A task-oriented approach to intervention focuses on all levels in which deficits are exposed (p543). To improve function in most cases, it is important to practise the task itself such as handwriting or ADLs and their specific components (p553).

Recommendation 24

We recommend using task-oriented approaches to improve motor tasks or selected activities based on goal-setting (LOE 1, level A).

9.2.2 Specific recommendations

9.2.2.1 Intervention methods on activities and participation NTT and CO-OP may be suggested as a task-oriented intervention method for children with DCD (SDDMF). NTT may be an effective treatment to improve gross and fine motor skills for children with DCD (SDDMF). The tasks that were being trained improved.[193,196] Two other studies used task-oriented NTT adapted for children with handwriting problems.[203,204]

Children with DCD (SDDMF), with or without comorbidities, receiving CO-OP can generate more effective strategies than those receiving the current treatment approach consisting of combination of neurodevelopmental, multi-sensory, biomechanical, and functional approaches, with most commonly sensory–integrative and fine and gross motor activities.[185,187] Children with a better verbal ability made more progress in motor skills, which may be because of their capability of understanding CO-OP.[187] Further studies, a meta-analysis, and the International Leeds Consensus from 2006 also support the use of task-oriented approaches like CO-OP and NTT.[1,174,176,188,189,194,205] Therefore, we feel that task-oriented intervention methods like CO-OP and NTT may be particularly useful to children with DCD (SDDMF) who are eligible for intervention. However, further evidence, for example from randomized controlled trials, is needed to prove the efficacy of the task-oriented approaches to improve function of children with DCD in daily life.

Recommendation 25

Task-oriented approaches like the CO-OP and NTT may be recommended as intervention in children with DCD (SDDMF) (LOE 2, level B).

9.2.2.2 Intervention methods on body functions and structures Children with DCD (SDDMF) have many symptoms connected with impaired body functions (see section 7.2.1). Earlier-developed treatment approaches focused on improving these body functions based on hierarchical theories of the nervous system and the hypotheses that better body functions would lead to improvement of activities. Studies (with the mentioned limitations of quality) showed that these approaches may sometimes be effective but less so than the task-oriented approaches which are based on motor learning theories.[194]

9.2.2.2.1 PMT Karvale and Mattson presented a meta-analysis of over 180 studies (before 1983) using a variety of PMT programmes.[206] Results of the meta-analysis indicated that perceptual–motor training programmes are not effective for improving the perceptual–motor, academic, or cognitive performance of children with mental retardation. The mean effect size of 0.082 indicated that children receiving perceptual–motor training performed only slightly better than those who did not receive any training. In general no improvement in academic skills was found and only very modest effects on perceptual–motor abilities. The authors concluded that through the use of meta-analysis there was sufficient empirical evidence to assess the efficacy of perceptual–motor training. They further concluded that the evidence obtained did not support the use of such training.

The more recent systematic review by Hillier[186] came to the following conclusion: of the nine studies investigating PMT, eight demonstrated that it had a positive effect.[96,192,207–212] However, no effect sizes were reported. Thus, it cannot be said how relevant these effects are.

9.2.2.2.2 SIT More than 18 years ago the literature regarding the effectiveness of SIT was already reviewed for the first time.[213] This analysis of seven randomized controlled studies failed to support the effectiveness of SIT intervention. The authors concluded that SIT was at best, as effective as other treatments or as effective as no treatment (comparison group). The next meta-analysis came from Vargas and Camilli.[214] They focused on sensory integration treatment defined as treatment that aimed at enhancing basic sensory integration processes with activities that provide vestibular, proprioceptive, tactile and somatosensory inputs to elicit adaptive body responses. They included many small sample studies from between 1972 and 1994. Their effect sizes for studies comparing SIT with no treatment were 0.60 for early studies (1972–1982) and 0.03 for more recent studies (1983–1993). The more recent studies showed that children receiving SIT improved no more than those who received no treatment at all. If SIT was compared with alternative treatments (not specified) the effect size on motor outcomes for early studies was 0.63, whereas the more recent studies with better designs showed an effect size of −0.04. In other words, when SIT has been compared with alternative treatments, there has been no difference in effect.[214]

Pless and Carlsson[200] performed a meta-analysis on intervention studies published between 1970 and 1996. They compared effect sizes of SIT and kinesthetic training (together called sensory integration) with treatments using skill training through task-specific or cognitive approaches. Despite methodological problems of the meta-analyses it has to be noted that large differences were found in the effect sizes, 1.46 for specific skill training and 0.21 for sensory integration. The authors therefore recommend a specific skill training approach for children with DCD (SDDMF) and advise that therapists dispel the notion of directly improving academic and motor performance by training based on the SIT approach.

A systematic review by Hillier[186] reported six out of seven studies using SIT with 'significant' effects. However, effect sizes were not calculated and therefore it is questionable whether these effects are relevant. Further, Hillier ignored the fact that the study effects 'decrease' over time, as shown by the meta-analyses from Vargas and Camilli[214] and from Pless and Carlsson.[200] Therefore, they came to a positive conclusion on SIT.

Studies evaluating SIT published after 1995 are Allen and Donald[215] using a one-group pre–post design with only five participants, Davidson and Williams[216] using retrospective data, Leemrijse et al.[217] with six participants using a cross-over design, and Cohn[218] a descriptive study using transcribed telephone interviews. All of these studies lead to inconclusive evidence about the effectiveness of SIT. Davidson and Williams conclude that a combined approach of SIT and perceptual motor intervention of 10 sessions is likely to be ineffective with children with DCD (SDDMF). A recent study reports on 8 months' occupational therapy for preschool children (n=44) aged 4 to 6 years with a score of 1.5 SD or more below the mean on the Peabody Developmental Motor Scales–Fine Motor.[219] They received weekly direct occupational therapy. The purpose of this study was to examine how performance components and variables in occupational therapy intervention influence fine motor and functional outcomes in preschool children with fine motor delays. The outcome was that play and peer interaction during treatment sessions were the only significant predictors for change. The SIT therapy did not account for any progression. The authors concluded that therapy might be more effective when therapists succeed in engaging 4- to 6-year-old children in peer interaction and play.

9.2.2.2.3 Kinaesthetic therapy Two older studies came to conflicting conclusions. In their well-controlled study, Polatajko et al.[220] found only improvements of kinaesthetic acuity but not in kinaesthetic perception and memory nor changes in visuomotor function using kinaesthetic therapy. A study from Sims et al.[180] reports positive results in several kinaesthetic functions.

In a recent systematic review, four studies with positive effects are summarized.[186] Without calculating effect sizes and looking at the specificity of the effects the effectiveness was regarded as moderate.

Looking more closely at the studies, for example the randomized controlled trial from Sudsawad et al.,[221] puts into question a specific effect of kinaesthetic therapy.

Statement 4 (++) on body-function-oriented approaches
Interventions that aim at improving body functions and structures may be effective but it seems that they are less effective in improving activities in children with DCD (SDDMF) than task-oriented approaches.[194]

Statement 5 (++) on body-function-oriented approaches
- PMT may be an effective intervention method for children with DCD (SDDMF)[186] (LOE 2).
  - The evidence is inconclusive for the effectiveness of SIT as an intervention for children with DCD (SDDMF)[194,213] (LOE 3).
  - As there is no evidence for the specific efficacy on kinaesthesis and inconclusive evidence for the effectiveness of kinaesthetic therapy in children with DCD (SDDMF), it is not recommended[186,220] (LOE 3).

9.2.2.2.4 Manual–medical intervention Manual–medical interventions are used, for example, in physiotherapy in some countries to influence musculoskeletal structures and functions. The effect on motor functions and performance in children with DCD (SDDMF) is unclear.

Schildt[222] investigated frequency and expression of dysfunctions in the locomotor system of 72 children with motor problems, aged 6 and 11 years. In the 6-year-olds, dysfunctions of the head joints (O/C1) were found; in the 11-year-old group, segmental dysfunctions of the thoracic spine were more frequent. The necessity to treat segmental dysfunctions in this age was concluded.

A more recent study compared frequency and location of manual–medical and osteopathic dysfunctions in 13 children with ADHD with comorbid 'motor dysfunctions' (DCD) to an age- and sex-matched comparison group. The treatment of the dysfunctions did not improve or influence the ADHD symptoms but showed a slight effect on the motor problems. A causal relation between segmental dysfunctions and ADHD symptoms was disclaimed. The additional treatment of adjunctive manual–medical or osteopathic dysfunctions in children with ADHD with motor problems was recommended.[223]

In 2008, a study investigated 32 schoolchildren with eye–motor problems and manual–medical dysfunctions of the head joints and the sacroiliac joint. Contemporaneous motor developmental delay respectively motor problems were assessed. Children were treated manual-medically in combination with a sensorimotor training programme (PäPki). This treatment combination improved motor activity in general and especially eye–motor problems.[224]

There are many expert opinions related to the positive effects of manual–medical interventions on motor disturbances in the childhood; however, there is no evidence whether and how effective manual–medical interventions are related to DCD (SDDMF).

Manual–medical and osteopathic dysfunctions represent no causal relation to ADHD. Their treatment showed slight effects of comorbid motor problems in children with ADHD and are recommended.[223]

Manual–medical intervention in combination with a sensomotor training programme may be effective in the treatment of schoolchildren with eye–motor and motor problems in general.[224]

In conclusion, manual–medical dysfunctions are frequent in children with motor problems between the age of 6 and 11 years and motor problems and may be treated.[222] Manual–medical interventions are directed on segmental dysfunctions, understood as an expression of motor disturbances and not as DCD. Manual–medical and osteopathic dysfunctions probably are a consequence and not a cause of DCD. Nevertheless, manual–medical intervention may improve motor performance of involved children.[225] At the moment, studies on children being properly diagnosed as having DCD are lacking. Therefore, the role of manual–medical intervention remains unclear in DCD. More research is needed to clarify under which conditions and for which category of children manual–medical intervention is appropriate.

Recommendation 26

There is no evidence that manual–medical intervention is effective on the core symptoms of DCD (SDDMF) (LOE 3, level 0).

However, manual–medical intervention may be considered as additional treatment in children with motor problems and musculo-skeletal dysfunctions.

9.2.2.2.5 Training of gross motor functions and strength exercises Therapy often includes training of gross motor functions and strength exercises.

Statement 6 (++)

It is possible that training of gross motor functions and strength exercises may help a group of children to achieve motor competence (LOE 3).

9.2.2.2.6 Weight-bearing exercises Weight-bearing exercises[226] were investigated once in a randomized controlled trial and showed short-term effects. This approach has limited evidence for effectiveness. More research is needed to clarify under which conditions and for which kind of children strength exercises and weight-bearing exercises are appropriate.

9.2.2.3 Other therapeutic approaches 9.2.2.3.1 Motor imagery training Motor imagery training is a new cognitive approach developed by Wilson.[110] It uses internal modelling of movements which facilitates the child to predict consequences for actions in the absence of overt movement. In time and with practice, children use the knowledge of the relation between vision and internal feeling of the movement to make appropriate predictions about the consequences of self-produced movements; this reduces the errors in feedforward planning. As a strategy for learning feedforward planning it seems to work for some children. Motor imagery training was investigated only once in a randomized controlled trial and showed positive effects if combined with active training.[192] So the evidence for its effectiveness is limited.

Some children with DCD (SDDMF) have problems using motor imagery[192] (see section 7.2), deficits in anticipating perceptual information,[38] and/or difficulties with visual memory,[52] which perhaps limit their ability to use the visual rehearsal strategies necessary for motor imagery training. Motor imagery training may be a helpful strategy for some children but not for all of those with DCD (SDDMF). More research is needed to clarify under which conditions and for which kind of children it is appropriate.

Statement 7 (++)

We do not know yet if motor imagery training is effective in children with DCD (SDDMF) (LOE 3).

Research note 5

Motor imagery is a very new intervention method. It needs to be further examined before it can be evaluated.

9.2.2.4 Parent- and teacher-guided approaches Parent-assisted motor skills,[227] the approach according to le bon départ,[217] and guided parent or teacher intervention,[189] were investigated each in one controlled trial or in some lower-level study designs. There is not yet clear evidence for efficacy.

9.2.3 Supplements and Medication

9.2.3.1 Fatty acids No evidence was found that supplements of fatty acids plus vitamin E have an effect on motor functions. Fatty acids may have positive influence on reading, spelling, and behaviour in children with DCD (SDDMF).[228]

Recommendation 27

We do *not* suggest fatty acids plus vitamin E to improve motor functions as there is no evidence for an effect on motor functions (LOE 2, Bneg).

9.2.3.2 MPH There are indications that MPH has a positive effect on behavioural ADHD symptoms, quality of life, and motor symptoms (handwriting). Additional motor therapy will still be needed in about 50% of children with ADHD/DCD (SDDMF) receiving MPH, within multimodal treatment with educational and psychosocial assistance.[229] There are indications that the use of MPH may be favourable for children with combined ADHD and DCD (SDDMF) with specific problems in fine motor skills and in handwriting. Accuracy may improve, but writing could become less fluent.[230] But in motor learning processes, accuracy improves first over velocity and fluency. MPH should not be considered as the only therapy for children with both DCD (SDDMF) and ADHD. These children need additional

treatment and support to overcome specific functional problems for handwriting and drawing.

Further studies should measure the effect of MPH on a larger group of children with DCD (SDDMF) and ADHD, perhaps including those with DCD without ADHD as comparisons. A randomized controlled trial with a follow-up over a longer period would be desirable.

Recommendation 28

MPH may be applied in children with DCD (SDDMF) and comorbid ADHD to improve fine motor symptoms (handwriting).

We suggest MPH, where there is appropriate clinical indication for the use of MPH in children with ADHD and DCD (SDDMF) in combination with further treatment and support to overcome functional problems like writing and drawing (LOE 2, level B).

9.2.4 Approaches on the level of activities and participation

The main goal of intervention in children with DCD (SDDMF) is to enable the child to perform activities and to participate in situations that are important for a child and his family. This goal should lead therapists starting from a child-centred goal setting to intervention planning and intervention, to evaluation of the whole process. Our literature review substantiates the Leeds Consensus[1] for intervention. The Leeds Consensus states that intervention approaches should do the following.

- Contain activities that are functional and are based on those that are relevant to daily living and meaningful to the child, parents, teachers, and others. These should be based on accurate assessment and aim to improve the child's motor functions plus other attributes such as self esteem and confidence.
- Involve the child's wishes as key parts of the intervention process. This will usually include identifying functional tasks, choosing priorities, establishing targets for success, and engaging in monitoring their own progress.
- Involve several individuals who can contribute – parents, teachers, health professionals, coaches, and other family members – to enhance generalization and application in the context of everyday life.
- Accommodate the contextual life of the family taking into account family circumstances such as routines, siblings, finance, etc.
- Be evidence-based and grounded in theories that are applicable to understanding children with DCD (SDDMF). These theories should take into account the nature of the learning process in the developing child, the structure of the task and the environmental conditions that support skill acquisition.

The areas of activities for improvement by intervention include self-care, productivity, and leisure. Special attention should be given to balancing the efforts a child has to put into self-care, school, and development-promoting leisure activities. Play and sports should be considered as important activities.

9.2.5 The role of environmental factors

Regular exercise is essential for motor learning and skill acquisition and exercise in various environments for transfer to the context of daily living. Support from parents, teachers, and other significant persons in the child's environment is important for treatment success.

Parents and teachers need to understand the child's problems and difficulties in motor learning and skill acquisition. They have to know how to support the child's learning process and exercise, to adapt the learning process and the environment and to advise in structuring the daily life activities. Pless and Carlsson[194] conclude from their meta-analysis that intervention should be given at least three to five times a week (for skill training). However, currently there is no evidence about what frequency and duration of intervention is necessary for long-term success.

Recommendation 29 (GCP++)

We recommend professional instruction to educate and coach the parents. This should promote a supportive attitude of parents, nursery nurses and teachers so that they recognize and understand the specific problems of the child with DCD (SDDMF) and so help such children to get the opportunity to improve their motor abilities and their participation in daily activities (at home, school, leisure, sports).

Statement 8 (++)

Children with DCD (SDDMF) need ample opportunity to learn and practise movements and participate in daily activities (house, school, leisure, sports). Therefore support from parents and teachers and other related persons is important for regular everyday practice of home exercises in addition to professional treatment.

Quality of environment has an effect on the person's ability to carry out tasks. Children with DCD (SDDMF) may need adaptation of the physical environment at least on a transient basis to support functional tasks like eating, dressing and writing. There are no actual studies on the efficiency and impact of adaptation of the physical environment for children with DCD (SDDMF).

9.2.6 Personal factors

Different treatment approaches can be seen as different strategies to support learning.[231] Each treatment approach focuses on a special aspect in the learning process and requires special competencies from the child, for example verbal and cognitive skills in CO-OP or the concept of pretence in motor imagery. These prerequisites are dependent on age, experience, developmental stage and personality of the child. Learning is a highly individual process. Each child with DCD (SDDMF) has individual difficulties and abilities, and prefers individual learning strategies and solutions.[185] Therapists should know how to find the right strategies and to adapt learning processes. If children are young or less verbally or intellectually competent NTT may be a good way to start. Currently adaptations of CO-OP for younger children or children with comorbidities like ADHD are being developed.

As mentioned above, support from family, teachers, and significant others is important for treatment success. Whether this support can be given depends on the family structure and situation. There might be families that are not able to give the needed support.

Children start to compare their abilities with peers at the age of 5. This happens especially in sports and group games. The experience of failing in these activities has an effect on their self-esteem and self-efficacy. Often, the consequence is a lack of motivation and the avoidance of the activities which manifest the problem.

Criticizing the study from McWilliams,[232] Green and Chambers[233] even argue that the group therapy could have made the children worse as the progress was seen before treatment starting.

Therefore group settings should be considered carefully depending on age, severity of the disorder, the members of the group, and the goals of the intervention.

Recommendation 30 (GCP++)

We suggest considering carefully if a group setting is appropriate for a child.

Statement 9 (++)

- It is *not* suggested that children with DCD (SDDMF) at young ages (5–6y) participate in a non-specific group motor skill programme (LOE 2).[130]
  - Group therapy is suggested for some children with DCD (SDDMF), e.g. isolated graphomotor problems or DCD (SDDMF) with motor performance between the fifth and 15th centiles of a norm-referenced test.[58,186,194,195,199]
  - In children with borderline DCD (SDDMF) and in children with behavioural comorbidities, occupational group therapy can be a method to achieve a positive effect on their self-esteem.
  - Individual therapy may have more positive effects in children with severe DCD (SDDMF) (below the fifth centile of a norm-referenced test).[186,234]

9.2.7 Recommendations concerning specific treatment methods

9.2.7.1 Interventions on handwriting Writing is a complex activity that implies temporal and spatial coordination of movement based on sensorimotor abilities and visual and auditive perception. It is not an end in itself, but requires automatization of the movements to be able to concentrate on higher-order processes like text content, grammar, and syntax. In motor learning processes, accuracy improves first over velocity and fluency.[235] There is a significant relation between orthographic-motor integration-handwriting and the length and quality of handwritten text, and a stronger relationship between orthographic–motor integration typing and length and quality of computer-based text. The typing skills group showed significantly better scores on typing and quality of typewritten text than the journal group at posttest.

Children with DCD (SDDMF) often have difficulties in coping with such complex and simultaneous tasks. A few studies have evaluated handwriting training in children with DCD (SDDMF). Some other studies have looked at children with dysgraphia as the main motor problem.

In a randomized controlled trial,[221] the effect of kinaesthetic training on handwriting performance on 6- and 7-year-old children (n=45) with kinaesthetic deficits and handwriting difficulties was examined.

Children were divided into three groups: (1) kinaesthetic training group receiving runway task training and pattern task training; (2) handwriting group, letters and words and sentences to copy; (3) Comparison group received no training. The first two groups received six sessions of 30 minutes. There were highly significant improvements (p=0.001); however, this improvement was not significantly different among the groups. No significant difference was found between pretest and posttest for an Evaluations Tool of Children's Handwriting total word legibility scores. No significant change occurred over time and no changes from pretest to posttest were significantly different among the groups (p=0.52). Thus, differential effectiveness of the kinaesthetic intervention on handwriting performance was not demonstrated in this study.

Insufficent evidence is available to support the efficacy of multisensory training in children with handwriting disorders.[221,236] It is likely that cognitive approaches in children with dysgraphia are more effective than sensory training.[237]

Three different studies using a task-oriented approach to improve handwriting all showed significant improvement in individual session as well as individual help in the class room.

There is moderate evidence for handwriting therapy based on NTT.[196] It is likely that handwriting instruction using a combination of visual cues (arrows) and memory training (how to form the letters) is the most effective.[238] Adaptation of writing material does *not* lead to more legible or faster writing in 3- to 6-year-old children.[238–240]

Task-specific intervention with self-instruction may improve handwriting. On the other hand, there is no evidence that using non-task-specific training methods (e.g. keyboard training) improves graphomotor function in children with DCD (SDDMF).[203,204]

Recommendation 31

In children with poor handwriting, we suggest a task-oriented self-instruction method to improve the quality of the handwriting (LOE 2, level B).

Prewriting exercises seem to be promising for children with handwriting problems.[203] It is possible that training of fine motor tasks and pen use before starting handwriting remediation makes learning how to write legible letters easier.[241]

Recommendation 32

Prewriting exercises for children with poor handwriting may be considered (LOE 3, level B).

As this is an economic and preventive approach the recommendation was upgraded from level 0 corresponding to LOE 3 to level B.

9.3 Cost-effectiveness

No studies were found comparing treatment approaches in relation to cost-effectiveness. Studies about the long-term effect of the treatment approaches in relation to cost-effectiveness are needed. Also, no studies were found about the cost-effectiveness of medication in children with DCD (SDDMF) and ADHD either.

Therefore, the guideline group suggests that the intervention strategies being recommended have the best cost–benefit at the moment.

9.4 Further research questions

The review of the literature disclosed some problems in current intervention research.

- There are not enough studies with high levels of quality, i.e. controlled studies or randomized controlled trials with large numbers of participants.
- Hardly any studies comparing two or more treatment approaches exist so far.
- Furthermore, it is necessary for reliable evidence of effectiveness of treatment to have independent raters who are well trained and blinded.
- Even if a treatment approach is described it is not always clear how it is implemented in practice. To gain a new competence in activity or participation, therapists often use different methods, mixing task-oriented methods to acquire certain functions with process-oriented methods.

These problems lead to high costs for the studies. Non-pharmacological therapy evaluation should be put higher on the priority list of the organizations that support research and of health insurances paying for the treatments. The latter must have a great interest in improving the efficacy of treatment in children with DCD (SDDMF).

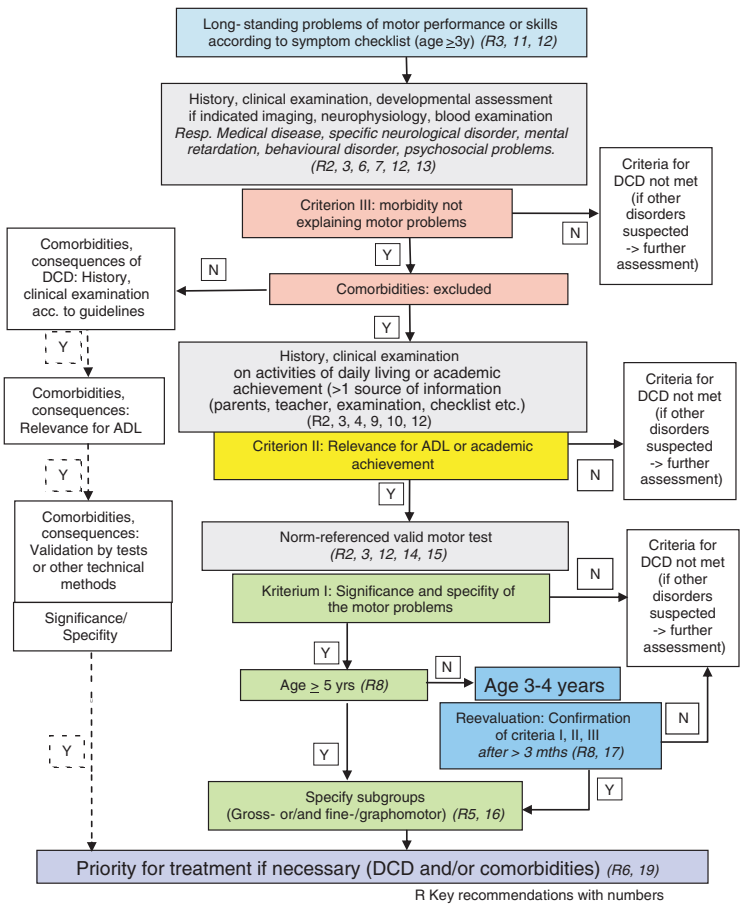
Research note 6

Urgently needed issues to be addressed in future research studies are as follows:

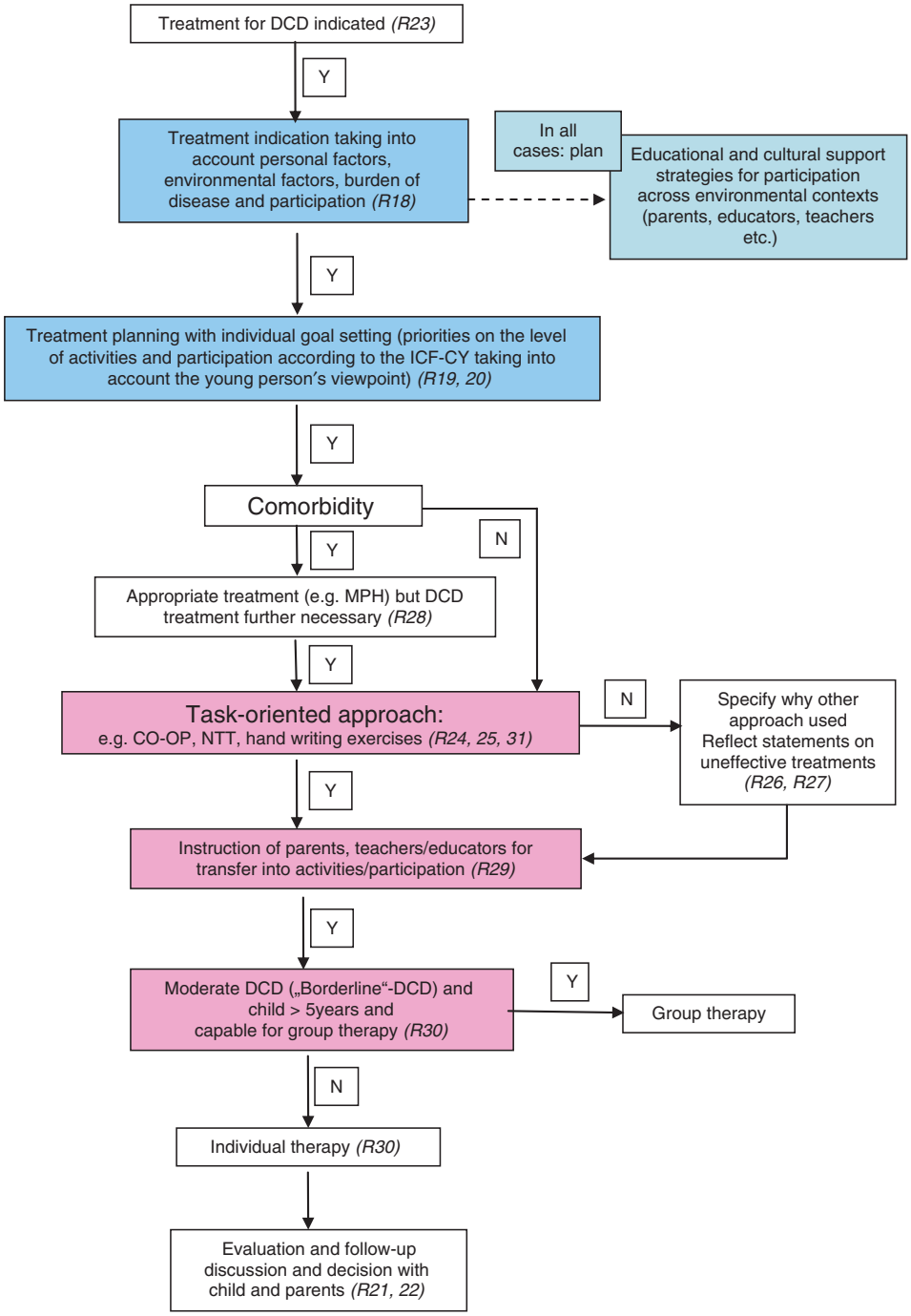
- Long-term effects of the various treatment approaches and cost–benefit aspects;
- Effectiveness of parent and teacher instruction;
- Effect and prerequisites of motor imagery training;
- Influence of environmental factors on performance;
- Methods for children and families with low verbal competencies;
- Methods for families with difficulties to support their children adequately;
- Prevention programmes for developmental delay in motor skills owing to deficit of experience and exercise.[242,243]

10 SUMMARY OF THE RECOMMENDATIONS: FLOWCHARTS

10.1 Assessment, treatment indication, and planning



10.2 Treatment planning, intervention, evaluation



11 QUALITY INDICATORS AND QUALITY MANAGEMENT

This section contains proposals for country-specific quality indicators and quality management (filled in by each country).

12 IMPLEMENTATION STRATEGY AND IMPLEMENTATION (COUNTRY SPECIFIC)

This section contains proposals for country-specific implementation strategies (filled in by each country).

13 APPENDIX I

13.1 Strategy used to search for, select, and appraise the evidence

1. Search on the international network of clinical practice guidelines (Guidelines International Network) to identify clinical practice guidelines on DCD (SDDMF).

2. Evidence from the literature based on meta-analyses, systematic reviews, or original research papers.

3. English and German terms describing DCD (SDDMF).

4. The following terms were used to identify relevant literature on DCD (SDDMF).

English: motor skills disorder, developmental coordination disorder (DCD [SDDMF]), clumsiness, clumsy, clumsy child syndrome, clumsy child, incoordination, dyscoordination, minimal brain dysfunction, minor neurological dysfunction/disorder, motor delay, perceptual–motor deficit/difficulties/dysfunction/impairment, developmental dyspraxia, dyspraxia, dysgraphia, developmental right hemisphere syndrome, movement disorders, motor impairment, motor skills disorder, motor coordination difficulties/problems, motor learning difficulties/problems, mild motor problems, non-verbal learning disability/disorder/dysfunction, sensorimotor difficulties, sensory integrative dysfunction, physical awkwardness, physically awkward, psychomotor disorders, deficits in attention, motor control, and perception (DAMP) and apraxias.

For the term using 'coordination', the alternative wording 'co-ordination' was also used. Terms including a hyphen (e.g. motor-impairment) were also searched for without the hyphen (e.g. motor impairment).

German: motorische Koordinationsstörung, umschriebene Entwicklungsstörung motorischer Funktionen, Ungeschicklichkeit.

5. The following databases were used to identify relevant literature on DCD (SDDMF): Medline, Cochrane-Library, PuBMed, CINAHL, PsycInfo, PsycLit, OTDBase, OTseeker, PEDRO, ERIC, HealthStar.

6. The following limits were applied:

humans, children, age younger than 18, adolescents, all references from January 1995 to January 2010;

research papers, reviews;

NOT cerebral palsy, stroke, ABI/traumatic brain injury, leukodystrophy, and muscular disorders.

13.2 Evaluation of the search strategy

1. No registered clinical practice guidelines were found using the international archive Guidelines International Network. No other clinical practice guideline using systematic reviews on evidence was found by manual search.

2. The literature search was performed for the time interval 1 January 1995 to 31 January 2010. Five hundred and twenty-two articles, reviews, book chapters, editorials, and comments were found by the search strategy. An additional 19 papers were found by hand search for the names of specific tests and questionnaires (total 541). A complete overview on the results of the systematic search is shown in Figure 2.

(a) On key question 1, only one older meta-analysis on underlying mechanisms[244] and one meta-analysis on consequences of physical abilities on self-esteem[245] were found.

(b) On key question 2, four comprehensive reviews on motor tests for DCD (SDDMF) were found.[110,140,246,247] One very recent systematic review (published after 1/2010) on tests of gross motor function (including DCD [SDDMF]) was added.[107]

(c) On key question 3 (treatment), two older meta-analyses were found[194,214] and one recent systematic review.[186]

13.3 Scoping of the literature and evidence tables

Figure 2: Scoping scheme on literature search for DCD (SDDMF).

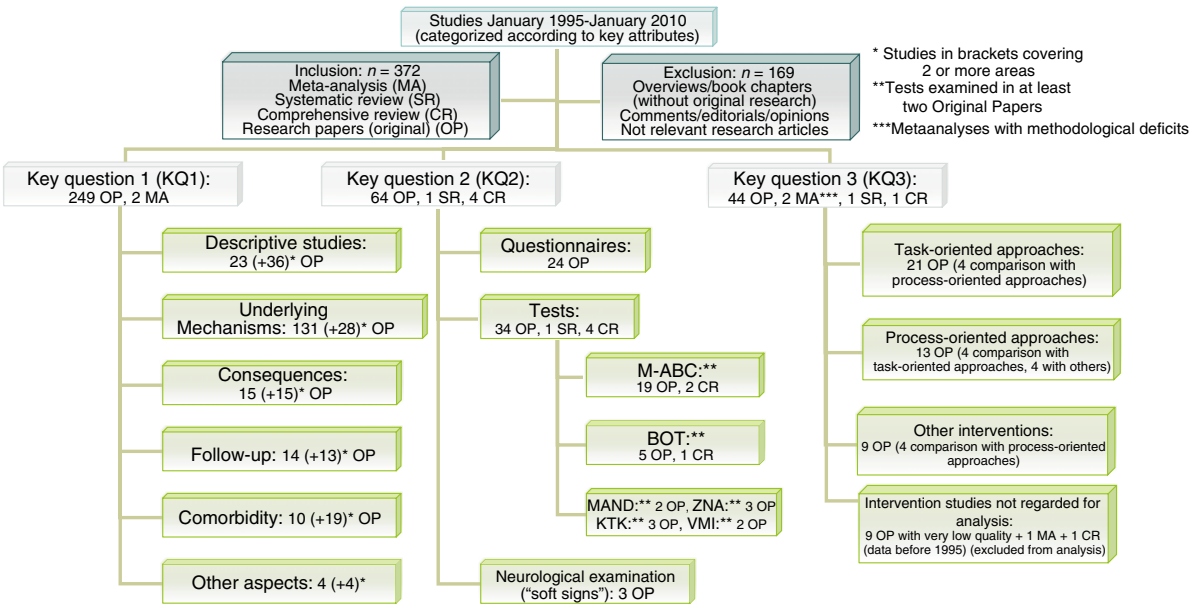


Figure 2: Scoping scheme on literature search for DCD (SDDMF).

13.4 Tables

Table VII: Evaluation of the published peer-reviewed literature[a]

Level of evidence	Grade	Oxford level	Oxford definition (diagnostic studies)	Oxford definition (intervention studies)
1 (High)	Evidence from a meta-analysis or systematic review of randomized controlled or other well-controlled studies with homogenous findings; homogeneity of the results. Very good quality of the results (e.g. validity and reliability measures >0.8).	Ia	Systematic review or meta-analysis of well-controlled studies with homogenous findings.	Evidence from a meta-analysis or systematic review of randomized controlled trials (with homogeneity).
	Evidence from at least one randomized controlled trial (intervention study) or well-controlled trial with well-described sample selection (diagnostic study); confirmatory data analysis, good standards (e.g. QUADAS rating >10). Very good quality of the results (e.g. validity and reliability measures >0.8).	Ib	Validating cohort study with good reference standard; clinical decision rule tested within on clinical centre, e.g. randomized/representative or consecutive sample; confirmatory statistics; prospective cohort study with good follow-up (>80%).	Evidence from at least one randomized controlled trial.
2 (Moderate)	Evidence from at least one well-designed, controlled study without randomization; sufficient standards (e.g. QUADAS rating >7); homogeneity of the results. Good quality of the results (e.g. validity and reliability measures >0.6).	IIa	Systematic review of level I or II studies.	Evidence from systematic review of cohort studies (with homogeneity) or evidence from at least one controlled study without randomization.
	Evidence from at least one well-designed other type of quasi-experimental study (non-randomized, non-controlled). Good quality of the results (e.g. validity and reliability measures >0.6).	IIb	At least one exploratory cohort study with good reference standards; clinical decision rule after derivation or validated on split-sample or databases or retrospective cohort study with consecutive sample.	Individual cohort study (including low-quality randomized studies, e.g. <80% follow-up). Evidence from at least one other type of quasi-experimental study.
3 (Low)	Evidence from well-designed non-experimental descriptive or observational studies, e.g. correlational studies, case–control studies, QUADAS rating >4; moderate homogeneity of the results. Moderate quality of the results, e.g. validity and reliability measures >0.4.	III	Non-consecutive cohort study or studies without consistently applied reference standards or descriptive study.	Evidence from case-control studies or evidence from observational studies.
4 (Very low)	Evidence from expert committee reports or experts.	IV/V	Evidence from expert committee reports or experts.	Evidence from expert committee reports or experts.

[a]According to the scientific evidence: levels of evidence (modified according to Oxford Centre for Evidence-based Medicine (March 2009) and to the Scottish Intercollegiate Guidelines Network (SIGN) www.sign.ac.uk/ 1999, hierarchy of evidence proposed by the United Kingdom National Institute for Health and Clinical Excellence) using the GRADE system.

Grading/scorings adopted from the German S3-Guideline for Childhood Obesity (2009, available at http://www.adipositas-gesellschaft.de/daten/Leitlinie-AGA-S3-2009.pdf) and from the GRADE Working Group.[248] QUADAS, Quality Assessment of Diagnostic Accuracy Studies. www.nice.org. uk/media/633/63/The_guidelines_manual_2009_-_Appendix_G_Methodology_checklist_-_the_QUADAS_tool_for_studies_of_diagnostic_test_accuracy.pdf

Table VIII: Descriptive results in the areas of activities and participation

Author	Year	Descriptive findings
Lefebvre and Reid[34]	1998	Predicting ball flight is more difficult for children with developmental coordination disorder (DCD) than their healthy peers.
Pless et al.[58]	2001	Parents of children with DCD were more supportive during physical activities and reported more worry and uncertainty in the handling of motor problems in their children.
Cairney et al.[56]	2006	One third of the effect of DCD on a simple aerobic enduring task (running) attributed to 'perceived inadequacy' (children perform less well, because they do not believe themselves to be as adequate as other children at physical activities).
Deconinck et al.[55]	2006	Problems in one-handed catching in male children with DCD not caused by impaired visuo-perceptual or planning processes but owing to problems in hand function.
Lloyd et al.[57]	2006	Boys with DCD have differences in emotional reaction and planning on a sport-specific problem-solving task (hockey shot), but *only* planning differences on an educational problem-solving task (peg solitaire task).

Table IX: Consequences with respect to activities and participation

Author	Year	Consequences
Hay and Missiuna[65]	1998	At the mean age of 12.5 y students with poor self-efficacy were found to have characteristics typical for developmental coordination disorder (DCD), but were not identified by teachers as having learning or behavioural disorder.
Smyth and Anderson[63]	2000	Children with DCD show less involvement in social physical play (team sports) and seem therefore more isolated and solitary during break in school.
Smyth and Anderson[249]	2001	Decreased participation in team sports like football may relate to the ability to maintain posture while performing other movements particularly with poor balance skills.
Segal et al.[70]	2002	Parents believed that their children's impairments restrict their participation in society.
Poulsen and Ziviani[62]	2004	Children with DCD are less physically active and show significantly different patterns of social and physical play than their well-coordinated peers. The impact of motor coordination problems on physical activity engagements throughout life is influenced by a multitude of factors (social, cultural, physical environment, individual characteristics).
Cairney et al.[64]	2005a	Regardless of sex, children with DCD had lower self-efficacy towards physical activity and participated i n fewer organized and recreational play activities than did children without the disorder. Although there were no sex by DCD interactions with self-efficacy and play, female children with DCD had the lowest mean scores of all children (9–14y).
Cairney et al.[66]	2005b	Children with DCD were less likely to be physically active; decreased generalized self-efficacy can account for a considerable proportion of this relationship
Cairney et al.[56]	2006	No evidence to support the hypothesis that children with DCD become more inactive compared with their peers as they age.
Cairney et al.[250]	2007a	In a questionnaire on self-perception, the effect of DCD on general pleasure/satisfaction was accounted for by 'perceived adequacy' in a large proportion.
Cairney et al.[72]	2007b	Lower cardiorespiratory fitness in children with DCD than children without DCD. 70% of male children with DCD scored at or below the 20th centile in respiratory peak flow velocity.
Poulsen et al.[251]	2007	Lower self-appraisals of perceived freedom in leisure and lower overall life satisfaction. Importance in relation to decreased team sport participation (male children 10–13y).
Schott et al.[71]	2007	Poorer performance in fitness tests with high demands on coordination.
Piek et al.[68]	2008	Significant correlation between motor ability and anxiety/depression with a moderate effect size (preschool-age children).
Poulsen et al.[67]	2008	Boys with DCD had lower general self-concept, global life satisfaction, task goal orientations, and perceived freedom of leisure (PFL); spent less time in social–physical activities than male children without DCD; and were lonelier than their well-coordinated counterparts. In those male children with DCD who participated in social–physical activities there was an increased PFL, which positively influenced relationships between motor ability and team sport participation and global life satisfaction.
Poulsen[252]	2008	Lower mean scores for energy expenditure (through sports activity) and self-concept appraisals of physical ability and physical appearance, but also peer relations, parent relations, and general self-concepts in children with DCD than without DCD.
Stephenson and Chesson[69]	2008	Parental reports (long-term follow-up): high persistence of problems; difficulties spanned motor and academic performance, emotional/behavioural responses and social interaction. Twenty-eight children (80%) of respondents were reported as having difficulties in three or more areas. Bullying was a commonly identified problem. Mothers feeling stressed and distressed, reported a lack of support and expressed feelings of isolation. They said that their time investment in their child with DCD had pronounced effects on themselves and other family members. They highlighted time spent fighting the system, primarily for educational support (a third of the sample also had attention-deficit–hyperactivity disorder).

Author	Year	Consequences
Summers et al.[60]	2008	Children with DCD needed greater level of structure and assistance. They required consistent prompting to complete tasks within allocated time. They were reported to be happier on holidays and weekends. Parents' expectations of independent performance were lower. Main factors that modified participation in daily routines were the child's age and their motor difficulties.
Summers et al.[61]	2008	Difficulties with postural control and fine-motor skills were reported to contribute to poorer performance of activities of daily living (children 5–9y).
Wang et al.[59]	2009	Pervasive impact of DCD on children's functional performance in daily activities at home and at school (children 6–7y).

Table X: Findings in studies on the outcome of developmental coordination disorder (DCD) for the level of activities and participation

Author	Year	Outcome
Visser et al.[77]	1998	In typically developing children, high velocities in physical growth are negatively related to motor competence, whereas high levels of activity showed a positive relationship with competence. In a comparison of motor competence in children with DCD and healthy controls, children with DCD catch up with controls to some extent during the growth spurt and one-third even reach full competence. Children with DCD were not affected by the growth spurt (longitudinal study during puberty)
Kadesjö and Gillberg[80]	1999	A diagnosis of DCD at age 7y predicts DCD at age 8y and restricted reading comprehension at age 10y.
Causgrove-Dunn[86]	2000	Physical education classes emphasizing a mastery motivational climate may result in higher perceived competence in children with movement difficulties
Christiansen[253]	2000	Everyday activities of male children with deficits in attention, motor control, and perception (DAMP) were significantly affected, and they chose to participate in different sports from the comparison male children, i.e. none participated in team sports.
Rasmussen and Gillberg[94]	2000	In the attention-deficit–hyperactivity disorder (ADHD)/DCD group, 58% had a poor psychosocial outcome compared with 13% in the comparison group with ADHD only. Remaining symptoms of ADHD, antisocial personality disorder, alcohol abuse, criminal offending, reading disorders, and low educational level were overrepresented in the ADHD/DCD group compared with ADHD without DCD.
Holsti et al.[105]	2002	Early-low-birthweight (ELBW) children more often have DCD. ELBW with DCD have more arithmetic problems.
Cantell et al.[81]	2003	In the educational domain, the adolescents with DCD (age 17y) had the lowest Wechsler Adult Intelligence Scale scores and shortest school careers of the three groups. In the social domain, the DCD group had the lowest perceptions of athletic and scholastic competence whereas the intermediate and comparison groups did not differ.
Cousins and Smyth[254]	2003	Adults with DCD performed more poorly than controls across all motor tasks. Slowness and variability of movement was a pervasive feature of their performance and many individuals had considerable problems with sequencing and with dual task performance. A discriminant function analysis conducted using six performance measures correctly classified participants as car drivers or non-drivers.
Cairney et al.[254]	2005	For male children, DCD may be a risk factor for overweight/obesity in childhood and early adolescence. For female children, there is no difference in the prevalence of overweight/obesity between children with and without the disorder.
Gaines and Missiuna[78]	2007	Young children who are in early intervention programmes for speech/language delays may have significant coordination difficulties; becomes more evident at kindergarten age (more demands in self-care and academic tasks).
Poulsen et al.[251]	2007	Participating in team sports acted as one potential mechanism mediating the inverse relationship between physical coordination ability and loneliness in male children
Kirby et al.[257]	2008	The study group of students in higher education consisted of 21 reporting to have DCD only, 38 with DCD plus another diagnosis (a combination of any of the following: dyslexia, attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), learning difficulties); 23 participants reporting dyslexia only, and 11 students who have not been formally diagnosed. The DCD group reported higher levels of motor related difficulties such as handwriting and executive functioning difficulties. The DCD only group lives at home with parents more often. A higher percentage of students with dyslexia than with DCD receive Disabled Students' Allowance. All students have similar types of support not dependent on their diagnosis.
Cairney et al.[258]	2010	Children with DCD reported less participation in organized and free-play activities than their typically developing peers, and these differences persisted over time. Among males, the gap in participation in free-play activities between those with DCD and typically developing children diminished substantially over time; among females, it increased slightly (population-based longitudinal study, 9y 0mo to 11y 11mo).

ONLINE MATERIAL/SUPPORTING INFORMATION

Additional tables and references for this article may be found online.

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