European Academy of Childhood Disability

EACD Recommendations

Long version**

Definition, Diagnosis, Assessment and Intervention of

Developmental Coordination Disorder (DCD)

Version – July 2011

* Terminology in this document is consistent with that of the International Classification of Functioning (ICF)
**Long version without countryspecific chapters (Implementation strategy, quality management)

Organisations and Representatives

These recommendations were approved at two Consensus Conferences in Maulbronn (Germany) (26th/ 27th March 2010 and 15th/16th 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, reg. assoc., members: 154 Specialty Societies). The AWMF represents Germany in the Council for International Organizations of Medical Sciences CIOMS (for further information see www.awmf.de).
The key recommendations of the Clinical Practice Guideline on DCD for Germany and Switzerland are identical with the recommendations on DCD consented by an expert panel initiated by the European Academy of Childhood Disability (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 definition, diagnosis, assessment and intervention of DCD in other countries.
The participants are summarized as follows:

Recommendations from the European Academy of Childhood Disability (EACD)

International society:
European Academy of Childhood Disability (EACD)

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

The recommendations were approved by an European panel of experts at the EACD meeting in Brusselles 26th , 2010 and through further DELPHI rounds.
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Teams, advisory board, coordination

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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).

Medical societies:
Neuropaediatric Society for German speaking countries (leading 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 Pediatrics
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:

Annette Mundt (Patient group representative from „Selbständigkeits-Hilfe bei Teilleistungsschwächen e.V.“ (SEHT e. V.))

Professional representatives (Germany, Switzerland):

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Johannes Buchmann (German Society of Child Psychiatry and Psychotherapy)
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Duration of the validity
The CPG was consented and written in March 2011. It is valid until the next revision, at the latest until March 2014. A revision is planned about every 3 years by the representative group and the international advisory board. In case of new knowledge or experiences, which have considerable influence on the recommendations of this CPG, the representative group and, if necessary, the international advisory board will rapidly produce the latest information.

Contents

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1 Introduction

1.1 Organisational 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 (Brusselles) and an international consensus, the International Leeds Consensus (2006) [1].

The CPG-DCD was formed by a nominal group consensus process chaired by an independent representative from the AWMF (Association of the Scientific Medical Societies in Germany). The AWMF represents Germany in the Council for International Organizations of Medical Sciences (CIOMS).

The CPG-DCD was initiated by the Neuropaediatric Society for German speaking countries (GNP). The GNP funded the second and third consensus conference in Germany.
The first consensus conference was connected with an international symposium in Maulbronn and funded by the Child Centre Maulbronn. The financial responsibilities were not covered 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 carried out 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 advisory board
3. National representatives of professional groups
4. Patient representative from a parent organisation

Because of a lack of research and recognized experts on DCD in German speaking countries it was regarded as necessary to involve a board of international experts. As DCD is defined differently in different countries, it was also necessary to initiate an international consensus to confirm and/or modify a previous international consensus (Leeds Consensus).
The CPG-DCD is in accordance with a recent international consensus (EACD recommendations, Brusselles 2010).

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, e. g. 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 metholodigical report on a S3-guideline [2].

The present document is the long version of the CPG-DCD. Further documents are a short version, a version for parents / nursery nurses / teachers and a short overview (algorithm). As a large proportion of the target group are children below the age of 8 years, the intention to write a child version has been dropped.

1.2General goals of the CPG-DCD

General goals of this guideline are:

1. to determine and prioritize key questions on etiology, 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 e. g. concerning the use of the ICD-10 vs. DSM IV
9. to provide an effective implementation strategy of the guideline by involving all medical and paramedical organisations 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:

- 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, health care services
- to help clarify responsabilities and propose models of co-operation among the various relevant professionals, e.g., by defining clinical pathways
- to help prevent long term consequences of DCD, e.g., by timely-effective intervention
- to raise community awareness for DCD

As 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 (DELBI).

1.3Target audience

The clinical practice guideline may be used by

- Health care professionals involved in the care of children diagnosed with or suspected DCD (physicians, therapists)
- Parents and nursery nurses, teachers or other educational professionals: adapted version

In order 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 parent-teacher/nursery nurse version will be provided.

2 Target group, scope, parent expectations

2.1Target 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 severe mental retardation are generally not identified as 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 to date has excluded these children from evaluation.

2.2Clinical relevance

DCD is a frequent disorder with estimates of 5-6% being the most frequently quoted percentage in literature [5, 6].
DCD 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 health care and educational professionals [8, 9].
On the other hand, there are considerable costs for longterm 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 (almost 80 million Euros) in 2006 reported by the AOK, the largest health insurance in Germany [10], alone. A total of about 400 million € are spent for sensomotor therapy in occupational therapy [10]. This is almost 50% of all occupational therapy interventions and over 90% of all occupational therapy sessions wirh children and adolescents under 15 years.

2.3Scope

There are a number of 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 Clinical Practice Guideline. The authors of the guideline hope to achieve improvements in the definition (national and international), the diagnosis and the 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 German speaking countries, e. g. there have been almost no original papers in international journals in the past 10 years coming out of Germany.

2.4Expectations of the patient representative

In order to ensure that the guideline is responsive to the expectations of the children and their parents, a parent organisation for children with learning disorders took part during the entire guideline process (Annette Mundt, SEHT e. V.). The following expectations were identified:

a. More awareness and recognition of the problem by the community, health care professionals, nursery nurses and parents
b. Improved access to services, particularly health care services
c. Establishing a clear diagnosis (transparency of diagnostic criteria, explaining the diagnosis and initiating the necessary examinations)
d. Better information about therapeutic options and types of therapy for parents
e. Information about effectiveness of intervention with respect to:
    i) Improvement of motor function
    ii) Improvement of performance in daily activities
    iii) Improvement of participation, particularly at school
f. 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 of an 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-IVTR in countries where DSM-IV-TR 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) and participation (home, school and community), personal and environmental factors. The question on impairment does not aim at specific clinical practice recommendations but aims 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 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 laboratory vs. natural settings.
The answer on 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); 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
A number of 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)?
- Are there barriers to access health care 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

4.1Areas 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 (priorisation) 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 Table 1 and Table 2.

Table 1: Target variables for outcome

Body function and structure	motor performance, basic motor skills
Personal factors	quality of life (wellbeing, 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 2: 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
Activites of daily living (self care etc. (basic ADL*), school performance, instrumental ADL**)			
Participation		1	1
Social integration (e.g. sport participation)***			
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
* Basic ADL (self care, toileting, eating – drinking etc.)
** Instrumental ADL (using a pen, scissors, playing with toys etc.)
*** Possible participation restriction as a consequence of activity limitations

5 Evaluation of the literature - methodological basis

5.1Recommendations based on evidence

Original papers addressing of key questions 2 (assessment) and 3 (treatment) were categorized according to the level of evidence using the GRADE system and the OXFORD system.
In contrast to intervention studies an established grading system for the different types of diagnostic studies does not exist. Therefore, the GRADE system and the Oxford definition had to be modified and adapted (see **Table** 7, Appendix).
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) limitations 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 rrelated to the level of evidence (**Table** 3 and **Table** 4).

Table 3: Levels of recommendations

Level of Evidence (LOE)	**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**

Table 4: 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 / the assessment to eligible residents	Good quality of evidence and substantial net benefits
B (Bneg.)	Recommended that clinicians (do not) routinely provide the intervention / the 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 / the assessment Insufficient evidence for recommendation of the intervention / the 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)

(adaptation from the Canadian Guide to Clinical Preventive Health Care and from US Preventive Services Resources**)**

5.2Recommendations based on formal consensus

A number of 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 less participants were present ≥90% agreement) is marked as GCP ++, a moderate agreement (=consensus ≥75 to 95% (90% if only 10 or less participants were present) is marked as GCP+.

6 Epidemiology

Current prevalence estimates for DCD range from 5% - 20% with 5-6% being the most frequently quoted percentage in the literature [13]. It is generally recognised that these children have problems with motor skills that are significant enough to interfere with both social and academic functioning [6]. Kadesjo et al.(1998) 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 (ALSPAC 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 2:1 to 7:1 [6, 7].

Although DCD is relatively common, it is still largely unrecognized by health care professionals and nursery nurses [8, 9]. Motor performance difficulties of children with DCD are often viewed as ‘‘mild” and, thus, not warranting attention as compared to the needs of children with more severe impairments such as cerebral palsy.

7 Definition, description, consequences, outcome, underlying mechanisms of DCD

7.1Definition

DCD occurs across cultures, races and socio-economicconditions. The disorder is idiopathic in nature, although a number of hypotheses for the cause of DCD have been recently proposed (see chapter 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 attention deficit hyperactivity disorder (ADHD), specific language impairment (SLI), learning disabilities (LD), autistic spectrum disorder (ASD) and developmental dyslexia or reading disability (RD). Some of these comorbidities are so strongly associated with DCD that DCD has been even regarded as a part of these disorders (e.g., autistic spectrum disorder and DCD is not allowed according to DSM IV classification; furthermore, the concept of Deficits in Attention, Motor control and Perception (DAMP) [14, 15] includes aspects of ADHD and DCD).

Since 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, WHO), 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 retardation or of any specific congenital or acquired neurological 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 chapter "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 4 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[1].
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 (Diagnostic and Statistical Manual of Mental Disorders, fourth Edition, Copyright 1994).
Looking at original papers the term “DCD” was used in 52.7%, “clumsy children” in 7.2%, “developmental dyspraxia” in 3.5% articles (see systematic review from January 1995 to December 2005 [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 (review by e.g. [17])**.**

7.1.3 Other definitions

The Dyspraxia Foundation (Great Britain) recommends the use of the term “Developmental dyspraxia” [18]. This term defines dyspraxia as “an impairment or immaturity of the organisation 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 chapter 7.2, pages 22ff) [20, 21].

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

Nonverbal learning disability (NLD) 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 *Diagnostic and Statistical Manual of Mental Disorders*, 4th Edition, Text Revision (DSM-IV TR). Many characteristics associated with NLD are similar to those that describe other, more "established" disorders, such as Asperger's Syndrome, specific learning disabilities and DCD.

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[1] The Leeds Consensus Statement (1. Sugden DA, Chambers M, Utley A. Leeds Consensus Statement 2006. Accessible at: wwwdcd-ukorg/consensushtml 2006) considers the high incidence of co-morbidity 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).

7.1.4 Recommendations on 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 which are currently available. The consensus of the guideline group also decided to use the DSM name DCD and their criteria. In Table 5 the official terminology for DCD is given as it applies to other languages.

Table 5: Terminology for DCD 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

Recommendation (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. The term DCD is taken from the DSM classification. However, in a number of 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 Appendix chapter 13.7, p. 112).

Recommendation (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:

- poor balance, clumsiness, dropping or bumping into things
- 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.

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 Clinical Practice Guideline for 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 Criterion C and D in the DSM-IV (the exception is the exclusion of autistic spectrum disorders, see recommendation 6).

Comments: Clarification of Criterion III

1. DCD (SDDMF) should not be diagnosed:
   - if motor performance cannot be assessed by a motor test (e.g., because of mental retardation or a medical disorder) or
   - 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 role 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 severe learning difficulties (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 recognised that 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 chapter 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 can not explain the motor problems and their impact on daily activities by cognitive status.

3. DCD (SDDMF) and coexisting diagnoses

It is widely recognised that children with DCD (SDDMF) often have coexisting diagnoses. It should be considered that ADHD, autism spectrum disorders (ASD) or conduct disorders (CD) 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 (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 (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, pre-vocational 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 (GCP++)

Children with DCD (SDDMF) having performance deficits in specific areas of motor performance (e.g., gross motor dysfunctions 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: Grapho-motor 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 grapho-motor or other fine motor problems may not justify the diagnosis of F82.1.

Recommendation (GCP++)

A dual diagnosis of DCD (SDDMF) and other developmental or behavioural disorders (e.g., ASD, learning disorders, ADHD) <u>should</u> be given if appropriate.

Comment for countries using DSM classification: recommendation 6a (see chapter 13.7, p. 112)
Dual diagnosis also serves the setting of priorities for intervention (see Statement 3 and Recommendation 18).

Recommendation (GCP++)

Co-morbidities should be carefully diagnosed and treated according to established clinical guidelines (e.g., ADHD, autism, dyslexia, specific language impairment).

Recommendation (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 carried out at sufficiently long intervals (at least 3 months).

Comment: According to the guideline group considerable problems exist for the diagnosis of DCD (SDDMF) in children below five years of age for the following reasons:
1. Young children may show delayed motor development with a spontaneous catch up (late bloomer).
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. indicates that motor assessment by the M-ABC2 has a very good test-retest reliability also for 3-year old children [25].
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 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 e. g. using the M-ABC [27], repeated assessment within short intervals (e. g. 3 weeks) 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 the disorder is stable 2 to 3 years later [29]. This supports the recommendation that in 3 to 4 year old children the 5th percentile 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).

7.2Description, 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]. A number of 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. found evidence for a global spatial processing deficit in children with DCD (SDDMF) [36]. Mon-Williams et al. on the other hand found difficulties in body-centered spatial judgments (esp. limb position) which may lead to an inappropriate relationship between perception and action [37].

Several studies consider proprioceptive dysfunction [38, 39] especially processing of kinaesthetic information [40, 41] as crucial in DCD (SDDMF). Volman et al. 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 precued-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. found mainly prolonged duration of movements as in much younger children [48] while Missiuna et al. 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 [49].

In the last five years more refined techniques allow 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 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 [51]. He found further that children with DCD (SDDMF) showed diverging gait patterns (esp. gait length and trunk inclination) from normally 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 considered a parietal dysfunction [44]. This may relate to the former diagnosis of a "minimal cerebral dysfunction" which receives some support by the fact that prematurely born children are much more likely to develop DCD (SDDMF) [7]. Goez et al. [54] on the other hand found more often lefthandedness than righthandedness in DCD (SDDMF) thus implying a genetic variability.

In order to prioritize and clarify the main findings from the numerous studies on underlying mechanisms members of the guideline group carried out a careful meta-analysis (coordination: Peter Wilson and Scott Ruddock).
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 categorised 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 (ES) estimates ($k \geq 10$), the largest effect sizes were found for kinematic parameters associated with reaching and catching: kinematic catching (r = .92), and kinematic target-directed reaching within personal space (r = .82) and outside of personal space (r = .81) were the highest discriminating measures between DCD (SDDMF) and control groups. Large effect sizes were also found for pattern variability during gait (r = .58), static balance under postural control (r = .56), and measures of forward modeling including covert orienting (r = .57) and motor imagery (r = . 50). Moderate effect sizes were found for both visuospatial and verbal working memory (r = . 43 and .45, respectively).

Of those categories that yielded high magnitude effect sizes but with $k < 10$, high magnitudes were found for forward modeling: motor imagery ($r = .98$), and covert orienting that used valid and invalid precues ($r = .83$ and .83, respectively). Other high effect sizes were found for contralateral ($r = .95$) and ipsilateral ($r = .94$) target-directed aiming movements.

Taken together, these results suggest that children with DCD (SDDMF) show underlying problems in visual-motor translation (viz inverse modelling) for movements directed within and outside peripersonal space, adaptive postural control, and the use of predictive control (viz forward modeling) 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 5 studies were identified (see Table 8, Appendix).

The results can be summarized as follows:

- Two studies [34, 55] address the question of predicting ball flight. Lefebvre et al. 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. found in a small case-control-study of 9 boys that those with DCD (SDDMF) adapted as well as healthy boys to temporal structure and velocity of ball flight but showed less opening of the hand and slower closing on the ball than controls. They deduced that the boys with DCD (SDDMF) showed more problems in the executive plan rather than visuo-perceptive or action-planning processes. Again this is a very small studygroup.

- Two other studies [56, 57] address the question of emotional implication in children with DCD (SDDMF). Cairney et al. 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 every day life in children with DCD (SDDMF). In a much smaller study (10 boys) Lloyd et al. found differences in cognitive coping strategies for motor planning in different motor tasks (hockey shot and peg solitaire) in children with DCD (SDDMF) compared to healthy 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. 2001 addressed the measures taken by the involved parents in supporting their children (before the diagnosis is made). They find 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 [58].

7.3Consequences

The systematic search found 30 studies presenting data on the consequences of DCD (SDDMF) in different areas of the ICF. 18 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** 9, Appendix).

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 healthy 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 teenage children with DCD (SDDMF) [65, 66] and lower life satisfaction [67]. Indeed, Piek et al. found a significant correlation between motor ability and anxiety disorders at kindergarten age [68]. Behavioural problems but also problems in social interactions persisted in a longterm 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 healthy peers.

7.4Outcome

There are several studies which addressed the natural course of DCD (SDDMF) (see **Table** 10, Appendix). There is compelling evidence that DCD (SDDMF) persists well into adolescence [73-77] and persists in an estimated 50-70% 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 et al. 1999 found a 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 [80] than their healthy peers, especially in the arithmetic domain [81]. This aspect can be related to the known difficulties of some children with DCD (SDDMF) in the visuo-spatial plane.
Cairney et al., 2005 found in a big study group, a correlation between DCD (SDDMF) and subsequent development of obesity in boys, while there was no such consequence observed in girls. One explanation may be that the participation in team play activities and sport teams is diminished in children with DCD (SDDMF) [80, 82-84]. This may also be a reason why long term participation in social activities is generally reduced.
Concerning coping mechanisms, Causgrove et al., 2000 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.

7.5Burden 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 chapter 7.2, page 22).

7.6Comorbidities

There is strong evidence that DCD (SDDMF) is combined with a number of emotional, social and learning disorders [85].

In a number of children, it cannot always be answered to what extent behavioural problems are co-existing disorders or the consequences of longstanding negative experiences with clumsiness in everyday life. Kaplan et al. [86] 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)

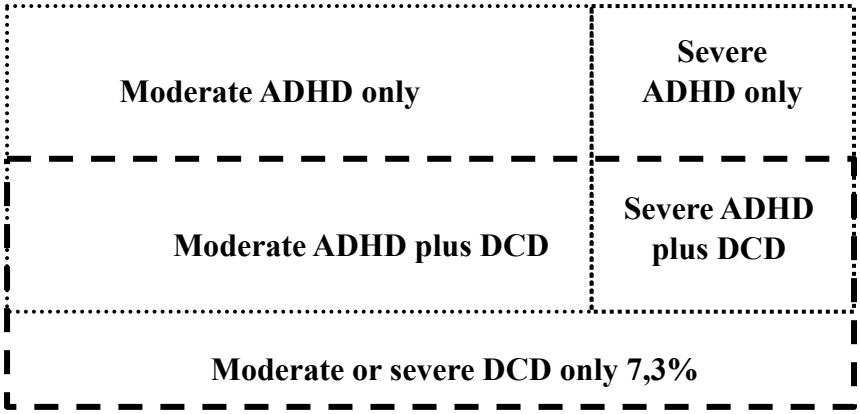
Regarding socioemotional problems as consequences and outcome, we refer to the chapters 7.3 and 7.4. The cooccurrence of DCD (SDDMF) and social, emotional and attential problems are well known [81, 87, 88].

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 about >50% of comorbidity [89]. 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 et al. (1999) describe that DCD (SDDMF) diagnosed at 7 year old Swedish children predicted reading comprehension at the age of 10 years [90]. DCD (SDDMF) itself remained stable at least within one year follow-up. In a further population-based study, Kadesjö et al. (2001) found that 87% of children with ADHD had comorbidities [91]. ADHD with DCD (SDDMF) seems to be more common in clinical and support groups than in school groups (in contrast to conduct problems etc.) [92].

A further study underlines the important clinical role of DCD (SDDMF) in context of ADHD. Rasmussen et al. [93] 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)) (see Figure 1, p.26).

Figure 1: Overlapping of ADHD and DCD (SDDMF)
(according to Kadesjö et al. 1998 [6])



The comorbidity of DCD (SDDMF) and specific language impairment has been shown in up to 70% of the children with language problems [79, 94-96].
Further, there are frequent comorbidities between DCD (SDDMF) and reading disorders and writing disorders [81, 86, 97, 98].

Coexisting learning disorder has been interpreted as an indicator for severity and for perceptual-motor dysfunction [99].
Montgomery et al. 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 [100] looked for cognitive deficits in children with DCD (SDDMF). Children with DCD (SDDMF) scored below average in the HAWIK/WISC-IV (verbal comprehension, perception reasoning, working memory and processing speed). The general IQ scored one standard deviation below the control group. Other studies report less differences of total IQ [38].
Alloway et al. [101] also found selective deficits in visuo-spatial 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.

Autism spectrum disorder (ASD) is also known to be associated with DCD (SDDMF) [96, 102, 103]. In a population-based study, a comorbidity of ASD was found in 10 of 122 children with severe DCD (SDDMF) and in 9 of 222 children with moderate DCD (SDDMF) [7].

Because of the comorbidities of DCD (SDDMF), ADHD, learning disorders and autism a common etiology has been discussed.
An overrepresentation of DCD (SDDMF) in preterm and low-birthweight children (about 2:1) is known [7, 104].
In a recent genetic study in a large group of twins a consistent comorbidity was only confirmed in severe cases. In this twin 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 to 7, in Table 6). 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.

Table 6: Comorbidities of DCD (SDDMF) with learning and behavioural disorder: Cluster analysis in a large twin study

Latent class*	Clinical feature	Frequency*	Percent*
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

*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 (ATAP) (developmental coordination disorder (DCD), attention-deficit/hyperactivity disorder (ADHD), reading disorder (RD), oppositional defiant disorder (ODD), and conduct disorder (CD) [105]

In conclusion, in spite of 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 e. g. 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 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 e. g. 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 4 (not systematic) reviews and overviews were found on this subject. Very recently, after the search period, a systematic review on measures of gross-motor functions was published [106]. 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 [107, 108]. 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 is not generally recommended. This has already been discussed above (chapter 7.1.4).

8.1Explanatory frameworks for different assessment approaches

According to the evaluative review by Wilson [109] the following assessment approaches can be distinguished:

a. *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.
b. *General abilities approach:* The guiding assumption here is that impaired sensory-motor 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, e.g. by the Sensory Integration and Praxis Test, and then should be a focus for treatment in order to improve motor functions.
c. *Neurodevelopmental theory (biomedical model)*: early neurological markers (e.g., clumsiness) predict disease states, e. g. "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 (MND)) will be tested. Normative data on soft signs are existing [110-112]. A new version of the examination of the Child with Minor Neurological Dysfunction is available [113]. The manual contains criteria, cut-offs and description of psychometric properties. Evidence is emerging that children with DCD often exhibit MND, in particular quite often the "complex form of MND" [114-116]. 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 MBD and MND for the development of a theory of DCD (SDDMF) has been questioned [109].
d. *Dynamical systems approach* [117]*:* This approach suggests that the child with DCD (SDDMF) has had reduced opportunities to form movement synergies via interaction with learning tasks and environment. Assessments used within this framework include biomechanical, kinematic, and observational analyses.
e. *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 toward 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; compared also chapter 7.2, pages 22ff).

8.2Questionnaires

Motor coordination test batteries are generally not feasible as screening protocols due to both time and costs. Researchers have argued for motor-based questionnaires that are completed by the child [107, 118], teachers [119-121] and/or parents [108]. 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 Movement-ABC-Checklist and its revised version (M-ABC2 checklist) [124, 125]

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:

- Early years Movement Skills Checklist [126]
- Children Activity Scales for Parents and Children Activity Scales for Teachers [127]

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 [128, 129]
- The Perceived Efficacy and Goal Setting System [49, 128]
- The Childrens Self-Perceptions of Adequacy in and Predilection for Physical Activity (CSAPPA) [107, 118]

These instruments may provide an idea of how the child perceives his/her disorder, but self-reports are not confirmed to be specific and sensitive assessment tools for the diagnosis of DCD (SDDMF), although there are some recent encouraging studies (see e.g., concerning the CSAPPA [107, 118]. There is a clear need of studies that evaluate if 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 on DCD (SDDMF) screening questionnaires are shown in Table 11, pages 78ff, Appendix.
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 (due 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 (4 studies, level 1b to 3b according to Oxford classification for diagnostic studies). The DCD-Q-R is currently translated into German and studies on psychometric properties are underway [122]. Studies to support recommendation 9 are summarized in Table 11 on page 78, Appendix.

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 Children's Self-Perceptions of Adequacy in and Predilection toward Physical Activity (CSAPPA) has been examined mainly by one research group (4 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 not validated in other European populations.

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 DCDQ-R (5 studies from 1997 to 2005,

level 1b to 3b), although this depends on the chosen cutoffs. However, this may be different in the new M-ABC2-Checklist (not yet translated and validated in German).

The Children's Self-Perceptions of Adequacy in and Predilection toward Physical Activity (CSAPPA) has been examined mainly by one research group (4 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 not validated in other European populations. A number of terms in this scale are specific to North America; e.g., the different settings for participation.

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 (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 Recommendation 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

Concerning criterion II: Questionnaires like the DCDQ-R or the MABC2-checklist may be recommended for use in those countries where the questionnaire is culturally relevant and standardised.

Research note 1
A reliable method of operationalizing Criterion II is urgently needed.

Recommendation

The use of questionnaires (e.g., DCDQ, M-ABC-Checklist) is not recommended for population-based screening for DCD (level A neg.).

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) [108].

8.3Clinical 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 etiology (pregnancy, birth, milestones, achievements, social contacts, kindergarten, school (grades, levels), previous and present disorders esp. 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, 130]

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, learning disorders
- Academic achievement

3) Views of the child should be taken into account (GCP++); child adapted questionnaires (see above) may be useful, but cannot be generally recommended (GCP++)

Recommendation (GCP++)

Concerning criterion I, II, III: Careful history taking is essential to support the application of Criterion 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 aquired 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 movments). Normative data on soft signs can be found in Largo et al. 2001 [110-112]. However, motor skills and speed only correlate weakly with soft signs: around 0.2

according to Gasser et al. [112]; 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 [131] [132] and older studies by Gillberg et al. [133-135] 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" [114-116] 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 MND 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 autistic spectrum disorders 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 (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 learning difficulties at school**

8.4 Assessment with standardized tests

According to the recommendations on definition of DCD (SDDMF) in chapter 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 focussed on the level of body structure and functions (according to the ICF), assessment using one of the following standardized tests is more focussed on the level of activities.

Within the literature search interval from 1995 to 2010 (January), 19 studies examining the **M-ABC** were found. 5 studies examined the **Bruininks-Oseretzky Test of Motor Proficiency** (BOTMP), 3 studies (including one from 2010) on the **Körperkoordinationstest for Children,** and 3 on the **Zurich Neuromotor Assessment Battery (ZNA).** The latter two tests have not been validated for the specific diagnosis of DCD (SDDMF). The **McCarron Assessment of Neuromuscular Dysfunction** (MAND) has also been used in several studies of DCD (SDDMF) and has shown good convergent validity (e.g. [136]).

A recent systematic review on assessment instruments in gross motor functions [106] comes to a similar conclusion. In this publication, seven measures of gross-motor function met the inclusion criteria and were appraised in regard to 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 The Movement Assessment Battery for Children (M-ABC, M-ABC2)

The **Movement Assessment Battery for Children** [124, 125] is by far the test most commonly used and best examined (see Table 12 and Table 13, Appendix).

The M-ABC-2 is a norm-referenced test for children from 3;0 until 16;11 years split in 3 age groups (M-ABC (first version) 4 until 12+ years, split in 4 age groups); compared to 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 (4;0 until 10;11years). 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 sound methodological background were included in the evaluation. In addition, the study samples used within the English, Dutch and German test manuals are taken into account.

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 cutoff (good sensitivity using the cutoff 15th percentile).

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 to 6 years)). The “discontinuation” of the scales moving from one age band to another may be a problem in longitudinal comparisons, when children, e.g. move from kindergarten to school age and for the comparison of children in first grade (6 to 7 years old). 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 gender effects have been found. This finding is in contrast with the findings of the Bruininks test (BOTMP, 2nd version, see chapter 8.4.1.2).

Comments on the M-ABC 2nd version

According to a consensus of international experts (EACD consensus conference in Brusselles 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. comparing Chinese children with American children found some cross-cultural differences [137]. Also, the Dutch norms suggest differences [138].

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 Bruininks-Oseretzky Test of Motor Proficiency (BOTMP, BOTMP2)

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 8 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 strength of movement, coordination, speed and dexterity of upper limbs, the speed of response, and visual motor control. The recent 2nd version of the BOTMP (BOTMP-2) provides norms from 4 to 21 years. The age norms have 4-months intervals in preschool children, half year intervals in school children and one year intervals in adolescents above 14 years. The instrument has separate norms for each gender.

Psychometric properties of the BOTMP and BOTMP-2

The BOTMP/BOTMP-2 shows good to excellent reliability, fairly good validity (construct and concurrent validity 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 inter-rater 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 [139].

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 [139]. (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 standardisation population is large and the reference values with 4-months 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 (MAND)

The MAND has mainly been used in Australia (2 studies) and is not further discussed (LOE 3) [136].

8.4.1.4 Other tests

A number of 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 1 to 3 published papers on test criteria (LOE (2) to 3). They may be suitable for testing motor abilities.

Examples are:

1. The **Zurich Neuromotor Assessment Battery (ZNA)** examines motor abilities (e.g., finger tapping), motor skills (static balance, pegboard, rope jumping) and associated movements (movement quality, soft signs) in 5-18 year old Swiss children and adolescents. Several studies have been published assessing the test-retest, interobserver and intraobserver reliability [140], construct validity [141] and the validity of the ZNA in former preterm children [142, 143]. Studies also presented age-related normative values (percentiles) [110, 111, 144] and examined the influence of age, gender and left-handedness on the motor tasks [112, 144]. 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 (KTK)** has undergone a recent revision. Test criteria, however, are only examined to some extent [145]. The most important requirement for test procedures is the need of actual norms [146]. In spite of 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 standardisation is not necessary because children may still have comparable motor performance [147, 148]. A number of studies have shown, however, that there is an alarming downward trend in motor ability over the last 40 years. The average MQ of the KTK has been shown consistently lower in all recent studies (MQ89 [149] and MQ89 [150] vs. MQ100 of the original version). Furthermore, the standardisation procedure from 1973/1974 is unclear. Bös [151] has expressed doubts on the exclusive measurement of coordinative performance by the KTK. 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 has been developed in the 1980s. A recent study from 2003 has shown that the

norms from the 1980s may still be valid. In contrast to school children, normative data for young children and preschoolers had not changed appreciably between 1987 and 2000 [152].

4. **PDMS (Peabody Developmental Motor Scales)** is a quantitative and qualitative assessment of gross- and fine-motor development in young children (birth to 5 years). 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 0-3. 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., DASH [153, 154] (UK norms) may be useful to diagnose a writing disorder (not available in Germany).
8. **SOS** (Systematische Opsporing van Schrijfproblemen) / **BHK** (Beknopte Beoordelingsmethode voor Kinder Handschriften) (BHK) [155-158] *(Dutch norms, French norms)* (Consise Assessment Methods of Children Handwriting [155] 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 five 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 inter-rater 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 BHK and the Dysgraphia Scale is reported to be 0.78 [158].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 SOS the most discriminating items were selected from the BHK, reformulated and concretised to develop the SOS test („Systematische Opsporing van Schrijfmotorische problemen“ or „Systematic screening of handwriting problems“) [159]. The SOS consists of six well- described criteria are used to evaluate the quality of the handwriting.screening. The child has to copy a text during 5 minutes. Writing speed is measured by counting the amount of letters [160]. Criterium validity with the BHK is good (r = 0.80-0.88, p = 0.01) [159, 161].
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 standardisation (German speaking countries / European countries) of the following tests have been found:

1. Münchner Funktionelle Entwicklungsdiagnostik
2. Ruf-Bächtiger-Test
3. Sensory Integration and Praxis Test (SIPT)

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

Recommendation (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 standardised 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 standardised motor test. It requires careful history taking, clinical examination and confirmation using valid tests and questionnaires (see chapter 8.2, pages 29ff and chapter 8.4, pages 32ff).

Recommendation

Concerning Criterion I: In the absence of a gold standard test for establishing Criterion I, the Movement Assessment Battery for Children (M-ABC-2) may be recommended (LOE 2, level B). Where available, the Bruininks-Oseretzky Test, 2nd version (BOTMP2) may also be recommended (LOE 2, level B). However, no German translation and standardisation of the BOTMP2 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 percentile for the total score (standard score 7 or less) should be used as a cut-off.

Comments:
Concerning the use of the M-ABC2 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-ABC2 in Germany.

In a comprehensive review, a distinction between Clinical Diagnostic Criteria and Research Criteria was postulated [162]. 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 a large number of children with moderate DCD (SDDMF) would be missed if using the 5th percentile. A number of studies examining the sensitivity and specificity of the M-ABC compared with other measures also used the 15th percentile. They found reasonably good agreement between measures when using the 15th percentile [163-167]. This view is also supported when population-based data are analysed [7, 90].
It is therefore plausible to use a cutoff level of 15th percentile in addition to criteria II and III.

The MOT4-6 may be considered for 4-6 year old children and the Zürich Neuromotor Assessment Battery (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 (GCP++)

Based on the limitations of the available instruments, classification of specific domains of dysfunction (e.g., gross motor or fine motor dysfunction (ICD-Nr. F82.0 and F82.1)), can be made on the basis of clinical judgement.
The use of gross motor or fine motor items of standardised assessments may be recommended alongside observation and reports of difficulties across relevant gross motor or fine motor and/or grapho-motor tasks.
The guideline group suggests the 5th percentile cut-off of the fine motor subdimension (e.g., M-ABC2, BOTMP2) 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, BOTMP2 and other tests) is not yet established by systematic research. Accordingly, the diagnosis of a grapho-motor disorder cannot be made on the basis of the M-ABC-2 and other motor tests alone. Where available, tests with country-specific standardisation may be recommended (e.g., for handwriting (e.g., DASH, BHK/SOS)).

If a child shows particular difficulties on one domain (i.e., performs below the 5th percentile), but performs above the 15th percentile 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 (GCP++)

Concerning Criterion I: For children between age of 3 and 5 years, if the diagnosis is needed (e.g., for treatment purposes), a cut-off of ≤5th percentile 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-ABC2, the BOTMP2 and other tests, the following aspects need to be addressed in future research:

- Discontinuity particularly between age bands in the M-ABC2 (specifically when transferring from age band 1 to age band 2) and therefore problems with longitudinal measurements (when becoming 7 years of age).
- Need for reliability testing within each age band (e.g., M-ABC2, BOTMP2).
- Possible floor effects[2] of the M-ABC2 (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 BOTMP2 and the ZNA include motor capacity items while the M-ABC2 test is mainly restricted to motor coordination and dexterity items).
- Further data on discriminative validity (e.g., sensitivity and specificity) are needed.

[2] Analogous to the ceiling effect, the floor effect means that in 6 out of 10 tasks in age band 1 the scoring values start with standard values above 5 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 standardisation).

- Norm-referenced and valid subtests (e. g. dimensions of the M-ABC2 or BOTMP2) for the DCD (SDDMF) subgroups with predominant fine motor or gross motor problems are needed.
- For German speaking countries, there is a need of a norm-referenced, valid test for handwriting.

8.5Treatment indication and treatment planning

Children with DCD (SDDMF) fulfilling the 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 (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 (incl. 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 (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, e. g. ADHD, treatment priorities need to be established. Individual factors, e. g. 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 school children, 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 (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 (s. chapter 9.2.1, page 45). 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 (COPM) [168] or the Goal Attainment Scaling (GAS) [169].

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

Recommendation (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 (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 3 months). The M-ABC can be used for evaluation of intervention over longer periods (e. g. 3 months 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

9.1Therapeutic approaches

Interventions for children with DCD (SDDMF) found in the literature are:

- Therapeutic approaches in occupational therapy and physiotherapy
- Supplementation and other treatment methods (s. section 9.1.2)
- 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 and Education

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

Occupational therapy (OT) offers children and adults methods to improve performance of everyday activities and participation in situations that are meaningful and important to them. OTs 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 e.g. process-oriented approaches like Sensory Integration Therapy (SI), 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 Table 11 - Table 13, Appendix). Great emphasis is given in OT to analyze and adapt the material environment and in counseling and educating the social environment**.** In addition to improved functional ability and participation, quality of life and life satisfaction are important goals of occupational therapy [170].

Physical Therapy (PT) enables children and adults to develop and optimize their mobility and movement-related functions. Purpose of the physiotherapy treatment is to achieve participation in meaningful life areas as independently and unaided as possible and with high quality of life. Treatment priorities are based upon information from 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 HOAC II (hypothesis-oriented algorithm for clinicians II) is commonly used to guide clinicians when documenting patient care and incorporating evidence into practice [171]. It helps to justify interventions for problems that require remediation and also those that may occur in the future and that require prevention. Physical therapists are specialized in analyzing 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 e.g. process-oriented approaches like adapted Neurodevelopmental Therapy (NDT), Sensory

integration (SI), strategic task-oriented approaches like Cognitive Orientation to Occupational Performance (CO-OP), or specific task oriented interventions like Neuromotor Task Training (NTT) and also adaptation of environment. They use tests like M-ABC2 or BOTMP in their assessments and parent-/teacher questionnaires to evaluate the motor development and performance of the children and their needs. Counseling and educating the social environment are important in physical therapy.

9.1.2 Supplements and Medication

Supplements and medication are often used in children with comorbidities e.g. ADHD. They are based on biological and neurological knowledge e.g. that fatty acids are needed in the development of the nervous system or that Methylphenidate 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 literature. Moreover, due 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)
- Cognitive-Orientation to Occupational Performance (CO-OP)
- Neuromotor Task Training (NTT)
- Contemporary Treatment Approach (CTA) or traditional approach
- Individual tutoring
- Motor Imagery
- Weight bearing exercises
- Writing exercises
- Parent-assisted Motor skills
- Movement-quality (effort) training
- Individual and group programs
- Psychomotor Training
- Le Bon Départ (LBD)
- Guided parent or teacher intervention
- Kinaesthetic Training
- Specific skills training

From this list:

- Some approaches are rather similar e.g. Contemporary treatment approach (CTA), traditional approach and Perceptual Motor Therapy (PMT)
- Some are only exercises e.g. 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 approaches
- Bottom-up and process-oriented approaches (also called deficit oriented) approaches.

9.1.4 Theoretical background

As described in chapter 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 [117] and the Neural Group Selection Theory [172-174]. 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 [173-175].
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 [172, 175]. Cognitive, behavioural and learning theories are also integrated into intervention methods.

9.1.5 Intervention process and orientation

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 e.g. Sensory Integration Therapy (SIT), Kinaesthetic Training, Perceptual Motor Training (PMT) or combinations:

- **Sensory Integration Therapy (SIT)** was developed in 1970s in the USA by the occupational therapist Jean Ayres [176]. The therapy provides sensory stimulation to promote motor development and higher cortical learning [175]. SI is still a popular method used by occupational therapists [173, 174]. The intervention expects to help children through providing proprioceptive, tactile/kinaesthetic, and vestibular stimulation aimed at remediating the proposed underlying sensory deficit.

- **Kinaesthetic Training (KT)** as described by Laszlo and Bairstow [177, 178]. Critical appraisals are made by Sims [179, 180]. 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 [173, 174].

- **Perceptual Motor Training (PMT)** is based on the idea that perceptual qualities and motor abilities are functionally linked [181]. It promotes learning through positive feedback and reinforcement [175].

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 [99]. A specific task is broken into steps which can be practiced independently and linked together to accomplish the entire task [174]. Therefore techniques from behavioural theory such as chaining or cognitive strategies from cognitive theory can be used [182, 183]. For active problem solving a cognitive approach is used [173]. Task-oriented approaches are Cognitive Orientation to daily Occupational Performance (CO-OP), Motor Imagery training (MI) and Neuromotor Task Training (NTT).

- **Cognitive Orientation to daily Occupational Performance (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 [175]. 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 [184]. Through such aspects as parent training and homework, the ability of problem-solving and skill acquisition is transferred to daily life.
- **Neuromotor Task Training (NTT)** was developed in the Netherlands [163]. NTT is a task-oriented training program 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), in order 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 via homework).

- **Motor Imagery training (MI)** developed by Wilson et al [109] 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 and this 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 pages 45).

As described in chapter 7.6 (from page 25), comorbidities like Asperger Syndrome, ADHD (Hyper- or Hypoactivity) or learning disabilities and perception disorders are often seen in children with DCD (SDDMF). Perception disorders for example can be e. g. 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 chapter 8.5, page 38).

9.2Recommendations and Statements

9.2.1 General recommendations[3]

In a systematic review of interventions on DCD (SDDMF), Hillier [185] 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 carried out a systematic literature search of studies published from 1995 to 2010 (see Table 14, in Appendix)

There is sufficient evidence that physiotherapy and/or occupational therapy intervention is better than no intervention for children with DCD (SDDMF) [186, 187, 188, 189, 190, 99, 191, 192, 179].

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

Recommendation

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 [193] 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 [175, 188, 191, 194-199]. It is shown that task-oriented approaches are effective in treating children with DCD (SDDMF) [193].

Looking at more recent studies and studies 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 controls are consistently larger than those being found in process-oriented approaches.
Individual or group programs are both effective ways of teaching task-oriented approaches.
Although the meta-analysis from Pless [193] 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 [173, 175, 187, 188, 192, 195]. Task-oriented approaches should also be used to improve motor performance when treating children in DCD (SDDMF) [193].
Task-oriented approaches using a cognitive approach demand certain requirements from children: The children 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 in order to react and respond to the intervention. Therapists therefore have to adapt their approach [200]. This may require that in some groups of children other approaches have to be used in addition. 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 also require occupational therapy treatment. No specific studies, however, have been found that evaluated differential treatment effects in groups of children with various co-morbidities.
Taking into account the huge body of evidence from the literature for effector-specific motor learning and since 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 [201]. Shumway-Cook et al. 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 (p. 538). Such task-specific training must be age-appropriate to enhance success (p. 539). A task-oriented approach to intervention focusses on all levels in which deficits are exposed (p. 543). To improve function

in most cases, it is important to practice the task itself such as handwriting or ADLs and their specific components (p. 553).

Recommendation

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

Neuromotor Task Training (NTT) and Cognitive Orientation to daily Occupational Performance (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 [192, 195]. Two other studies used task oriented NTT adapted for children with handwriting problems [202, 203].

Children with DCD (SDDMF), with or without comorbidities, receiving CO-OP can generate more effective strategies than children receiving 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 [184, 186]. Children with a better verbal ability made more progress in motor skills which may be due to the capability of understanding CO-OP [186]. 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, 173, 175, 187, 188, 193, 204]. Therefore, we feel that task-oriented intervention methods like CO-OP and NTT may be particularly useful to children with DCD (SDDMF) eligible for intervention. However, further evidence e.g. from RCTs is needed to prove the efficacy of the task oriented approaches to improve function of children with DCD in daily life.

Recommendation

Task-oriented approaches like the Cognitive Orientation to daily Occupational Performance (CO-OP) and Neuromotor Task Training (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 a great number of symptoms connected with impaired body functions (see chapter 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 effective than the task-oriented approaches which are based on motor learning theories [193].

9.2.2.2.1 Perceptual motor therapy (PMT)

Karvale and Mattson presented a meta-analysis of over 180 studies (prior to 1983) using a variety of Perceptual Motor Training und Therapy (PMT) programmes [205]. Results of the meta-analysis indicate that perceptual-motor training programs are not effective for improving the perceptual-motor, academic, or cognitive performance of learning disabled children. The mean effect size of .082 indicates that children receiving perceptual-motor training perform only slightly better than children 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 conclude that through the use of meta-analysis there is sufficient empirical evidence to assess the efficacy of perceptual-motor training. They further conclude that the evidence obtained does not support the use of such training.

The more recent systematic review by Hillier [185] comes to the following conclusion:
Of the nine studies investigating Perceptual Motor Therapy (PMT) eight demonstrated that PMT had a positive effect [95, 191, 206-211]. However, no effect sizes are reported. Thus, it cannot be said how relevant these effects are.

9.2.2.2.2 Sensory Integration Therapy (SIT)

More than 18 years ago the literature regarding the effectiveness of SIT was already reviewed for the first time [212]. This analysis of 7 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 (control group). The next meta-analysis came from Vargas et al. [213]. 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 somato-sensory inputs to elicit adaptive body responses. They included many small sample studies from between 1972-1994. 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 children who received no treatment at all. If SIT was compared to alternative treatments (not specified) the effect size on motor outcomes for early studies was 0.63, while the more recent studies with better designs showed an effect size of -0.04. In other words, when SIT has been compared to alternative treatments, there has been no difference in effect [213].
Pless and Carlsson [199] performed a meta-analysis on intervention studies published between 1970 and 1996. They compared effect sizes of SIT and kinesthetic training (together called SI) with treatments using skill training through task specific or cognitive approaches. In spite of 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 SI. 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 SIT approach.
A systematic review by Hillier [185] reported 6 out of 7 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 et al. and from Pless and Carlsson. Therefore, they came to a positive conclusion on SIT.
Studies evaluating SIT published after 1995 are Allen and Donald [214] using a one group pre-post design with only 5 subjects, Davidson and Williams [215] using retrospective data,

Leemrijse 2000 with 6 subjects using a cross-over design [216], Cohn 2000 a descriptive study using transcribed phone interviews [217]. 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 4-6 years old with a score of 1.5 SD or more below the mean on the Peabody Developmental Motor Scales-Fine Motor [218]. 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 of this study 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 4-6 year old children in peer interaction and play.

9.2.2.2.3 Kineaestetic Therapy (KT)

Two older studies came to conflicting results. In their well-controlled study, Polatajko et al. found only improvements of kinaesthetic acuity but not in kinaesthetic perception and memory nor changes in visuomotor function using KT [219].
A study from Sims et al. reports positive results in a number of kinaesthic functions [179].
In a recent systematic review, 4 studies with positive effects are summarized [185]. Without calculating effect sizes and looking at the specificity of the effects the effectiveness was regarded as moderate.
Looking more closer at the studies, e. g. the RCT from Sudsawad et al. puts into question a specific effect of KT [220].

Statement 4 (++)
Key statement 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 [193].

Statement 5 (++)
Statements for body function oriented approaches

- **Perceptual motor therapy (PMT) may be an effective intervention method for children with DCD (SDDMF) [185] (LOE 2).**
- **The evidence is inconclusive for the effectiveness of Sensory Integration Therapy (SIT) as an intervention for children with DCD (SDDMF) [193, 212] (LOE 3).**
- **The evidence is inconclusive for the effectiveness of Kinesthetic Therapy (KT) for children with DCD (SDDMF) (LOE 3)**
- **As there is no evidence for the specific efficacy on kinesthesis and inconclusive evidence for the effectiveness of Kinesthetic Therapy (KT) in children with DCD (SDDMF) it is not recommended [185, 219] (LOE 3).**

9.2.2.2.4 Manual-medical Intervention

Manual-medical Interventions are used e.g. in physiotherapy of some countries to influence musculo-sceletal structures and functions. The effect on motor functions and performance in children with DCD (SDDMF) is unclear.

Schildt (1987) [221] investigated frequency and expression of dysfunctions in the locomotor system of 72 children with motor problems, aged 6 and 11 years. In six year-olds, dysfunctions of the head joints (O/C1) were found; in the 11 year-old group, segmental dysfunctions of the chest spinal column were more frequent. The necessity to treat segmental dysfunctions in this age was concluded.
A more recent study compared frequency and location of manualmedical and osteopathic dysfunctions in 13 ADHD children with comorbid "motor dysfunctions" (DCD) to an age and gender matched control 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 manualmedical or osteopathic dysfunctions in ADHD children with motor problems was recommended [222].
In 2008, a study investigated 32 school children with eye-motor problems and manualmedical dysfunctions of the head joints and the sacroiliac joint. Contemporaneous motor developmental delay resp. motor problems were assessed. Children were treated manualmedically in combination with a sensomotor training programme (PäPki). This treatment combination improved motor activity in general and especially eye-motor problems [223].
There are a lot of expert opinions related to positive effects of manualmedical interventions on motor disturbances in the childhood, however, there is no evidence whether and how effective manualmedical interventions are related to DCD (SDDMF).
Manualmedical and osteopathic dysfunctions represent no causal relation to ADHD. Their treatment showed slight effects of comorbid motor problems in ADHD children and are recommended [222].
Manualmedical intervention in combination with a sensomotor training program may be effective in the treatment of school children with eye-motor and motor problems in general [223].

In conclusion, manualmedical dysfunctions are frequent in children with motor problems within the age of 6 and 11 and motor problems and may be treated [221]. Manualmedical interventions are directed on segmental dysfunctions, understood as expression of motor disturbances and not as DCD. Manualmedical and osteopathic dysfunctions probably are a consequence and not a cause of DCD. Nevertheless, manualmedical intervention may improve motor performance of involved children [224]. However, as long as there are no specific studies on children being carefully diagnosed as having DCD, the role of manual medical intervention remains unclear in DCD. More research is further needed to clarify under which conditions and for which kind of children manual-medical intervention is appropriate.

Recommendation

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-scelettal 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 in a group of children to achieve motor competence (LOE 3).

Weight bearing exercises

Weight bearing exercises [225] 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 is appropriate.

9.2.2.3 Other therapeutic approaches

9.2.2.3.1 Motor Imagery Training (MI)

Motor Imagery Training is a new cognitive approach developed by Wilson et al. 2005 [109]. 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 be working for some children. MI was investigated only once in a randomized controlled trial and showed positive effects if combined with active training [191]. So the evidence for effectiveness is limited.
Some children with DCD (SDDMF) have problems using motor imagery [191] (see chapter 7.2, from page 22), deficits in anticipating perceptual information [38], and/or difficulties with visual memory [52], that perhaps limit their ability to use the visual rehearsal strategies necessary for MI. MI may be a helpful strategy for some children but not for all of the DCD (SDDMF) children. More research is needed to clarify under which conditions and for which kind of children MI is appropriate.

Statement 7 (++)
We do not know yet if MI 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 [226], the approach according to Le Bon Départ [216] and guided parent or teacher intervention [188] 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) [227].

Recommendation

We do <u>not</u> suggest fatty acids + vitamin E to improve motor functions as there is no evidence for an effect on motor functions (LOE 2, B neg.).

9.2.3.2 Methylphenidate

There are indications that MPH has a positive effect both on behavioural ADHD symptoms, quality of life and motor symptoms (handwriting). Additional motor therapy will still be needed in about 50% of the children with ADHD/DCD (SDDMF) receiving MPH, within multimodal treatment with educational and psychosocial assistance [228]. 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 [229]. 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 in with DCD without ADHD as controls. A randomized controlled trial with a follow-up over a longer period of time would be desirable.

Recommendation

Methylphenidate may be applied in children with DCD (SDDMF) and comorbid ADHD to improve fine motor symptoms (handwriting).
We suggest Methylphenidate, where there is appropriate clinical indication for the use of Methylphenidate 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 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

- 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 a **number of 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 [193] conclude from their meta-analysis that intervention should be given at least 3-5 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 (GCP++)

We recommend professional instruction to educate and coach the parents. This should promote a supportive attitude of parents and nursery nurses/teachers so that they recognize and understand the specific problems of the child with DCD (SDDMF) and so help the children with DCD (SDDMF) 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 practice movements and their participation 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 DCD (SDDMF) children.

9.2.6 Personal factors

Different treatment approaches can be seen as different strategies to support learning [230]. Each treatment approach focuses on a special aspect in the learning process and requires special competencies from the child e.g. 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 [184]. 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 which 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 Williams et al. [231], Green and Chambers even argue that the group therapy could have made the children worse as the progress was seen prior to treatment starting [232].
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 (GCP++)

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

Statement 9 (++)

- **It is <u>not</u> suggested that children with DCD (SDDMF) at young ages (5-6years) participate in a non-specific group motor skill program (LOE 2) [129].**
- **Group therapy is suggested for some children with DCD (SDDMF) , e. g. isolated graphomotor problems or DCD (SDDMF) with motor performance between the 5th and 15th percentile of a norm-referenced test [58, 185, 193, 194, 198].**

- **In children with borderline DCD (SDDMF) and in children with behavioural co-morbidities, 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) (< 5th percentile of a norm-referenced test) [185, 233].**

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 sensori-motor abilities and visual and auditive perception. It is not an end in itself, but requires automatisation of the movements in order 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 [234]. 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 post-test.

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 randomised controlled trial [220] the effect of kinesthetic 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 3 groups: 1. Kinaesthetic training group receiving runway task training and pattern task training, 2. Handwriting group, letters and words and sentences to copy, 3. Control group received no training. The first 2 groups received 6 Sessions of 30 minutes. There were highly significant improvements (p=.001), however this improvement was not significantly different among the groups. No significant difference was found between pre-test and post-test for an Evaluations Tool of Children`s Handwriting (ETCH) total word legibility scores. No significant change occurred over time and no changes from pre-test to post-test were significantly different among the groups (p=.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 [220, 235]. It is likely that cognitive approaches in children with dysgraphia are more effective than sensory training [236].

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 [195]. 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 [237]. Adaptation of writing material does not lead to more legible or faster writing in 3 to 6 year old children [237-239].
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) [202, 203].

Recommendation

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 [240].

Recommendation

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.

9.3Cost-effectiveness

No studies were found comparing treatment approaches in relation to cost-effectiveness. Studies about the longterm 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.

9.4Further 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 RCTs 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 to improve the efficacy of treatment in children with DCD (SDDMF).

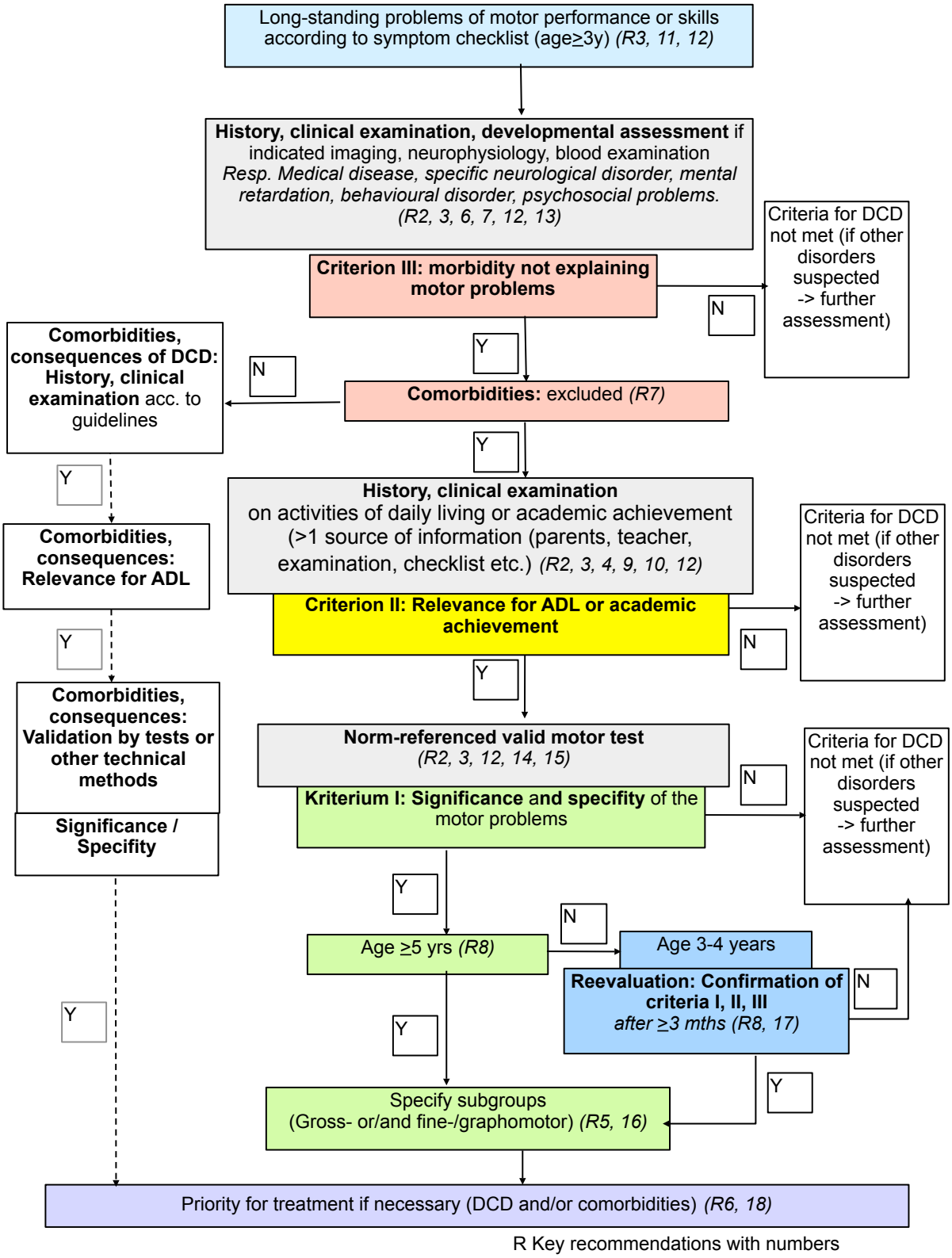
Research note 6

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

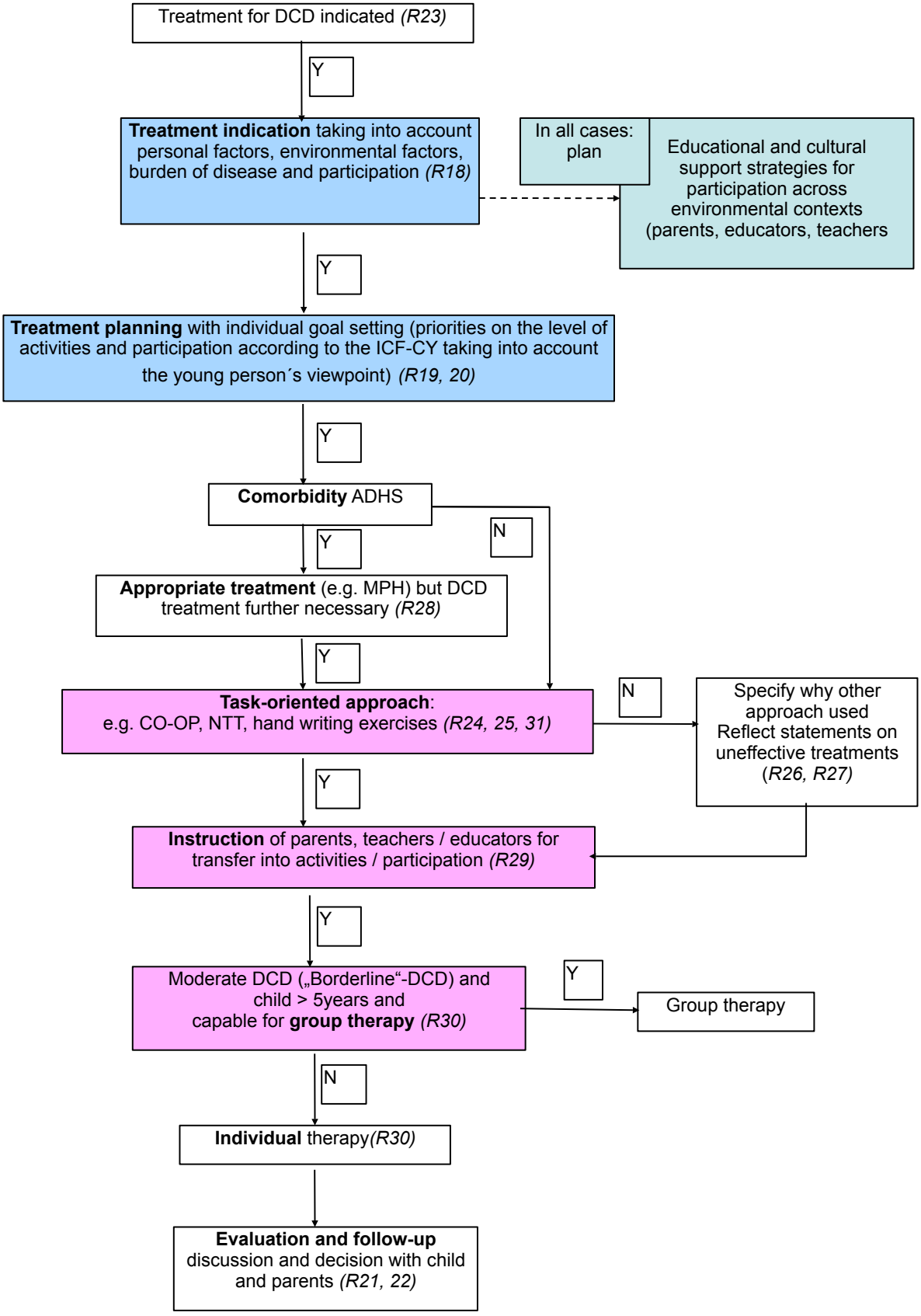
- long-term effects of the various treatment approaches and cost-benefit aspects
- effectiveness of parent and teacher instruction
- effect and prerequisites of Motor Imagery training
- influence of environmental factors on performance
- methods for children and families with low verbal competencies
- methods for families with difficulties to support their children adequately
- prevention programs for developmental delay in motor skills due to deficit of experience and exercise [241, 242].

10 Summary of the recommendations: Flowcharts

10.1 Assessment, treatment indication and planning



10.2Treatment planning, intervention, evaluation



11 Quality indicators and quality management

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

12 Implementation strategy and implementation (country specific)

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

13 Appendix

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

1.Search on the international network of clinical practice guidelines (G-I-N) 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 a dash „-“ (e.g. motor-impairment) were also searched for without the dash (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.

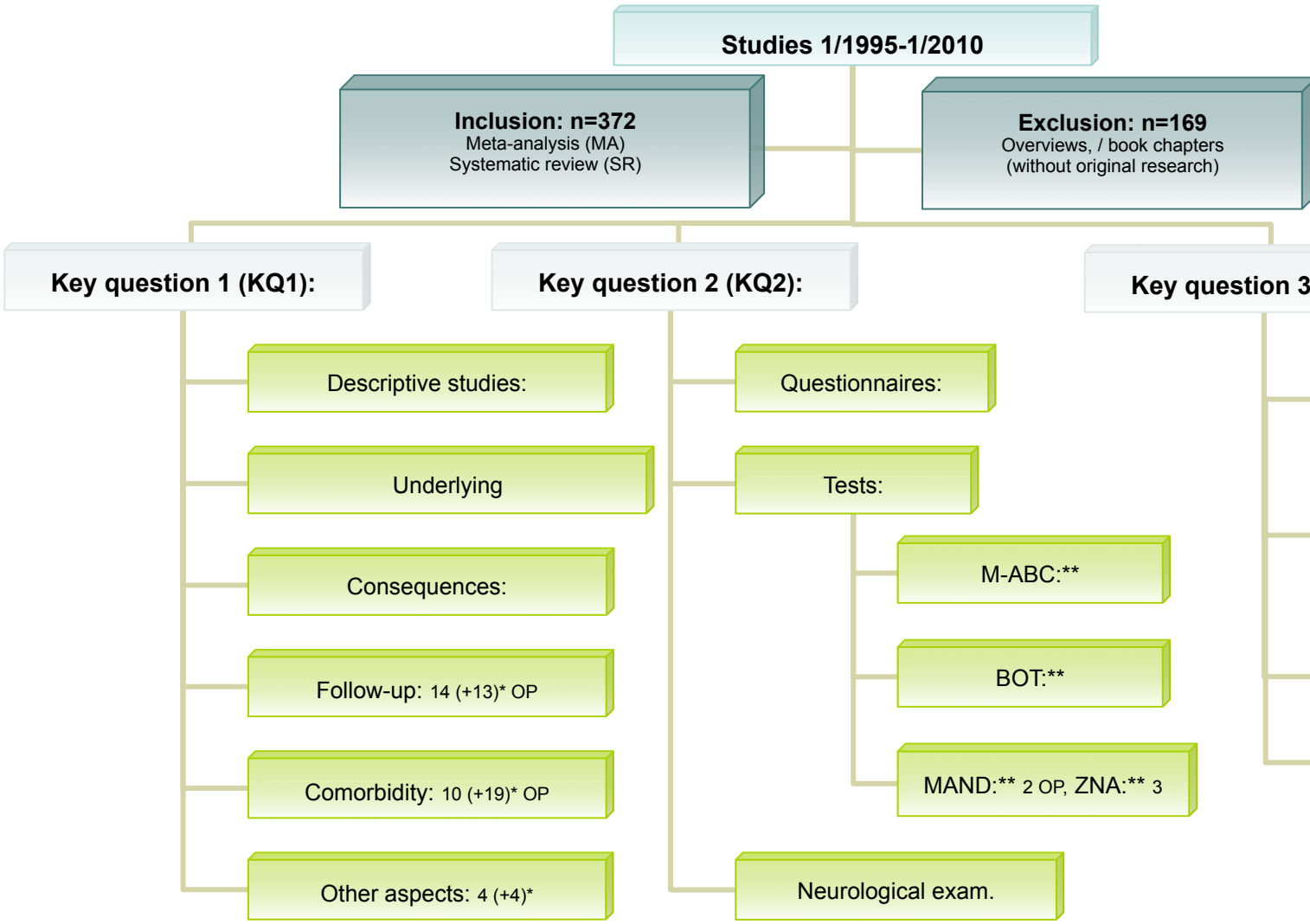
4. The following limits were applied:
humans, children, age <18, adolescents, all references from January 1995 to January 2010. Research papers, reviews.
NOT cerebral palsy, stroke, ABI/traumatic brain injury, leucodystrophia and muscular disorders.

13.2Evaluation of the search strategy

1. No registered clinical practice guidelines have been found using the international archive G-I-N. No other clinical practice guideline using systematic reviews on evidence has been found by manual search.
2. The literature search was carried out for the time interval 1.1.1995 to 31.1.2010. 522 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 on page 73.
    a. On key question 1, only one older meta-analysis on underlying mechanisms [243] and one meta-analysis on consequences of physical abilities on self-esteem [244] were found.
    b. On key question 2, four comprehensive reviews on motor tests for DCD (SDDMF) were found [109, 245, 139, 246]. One very recent systematic review (published after 1/2010) on tests of gross motor function (including DCD (SDDMF)) was added [106].
    c. On key question 3 (treatment), two older meta-analyses were found [213, 193] and one recent systematic review [185].

13.3Scoping of the literature and evidence tables

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



13.4Tables

Table 7: Evaluation of the published peer-reviewed literature*

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)	I a	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)	I b	Validating cohort study with good reference standard; clinical decision rule tested within on clinical centre. E. g. randomised / 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)	II a	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-randomised, non-controlled) Good quality of the results (e. g. validity and reliability measures >0.6)	II b	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 (incl. low quality randomised 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

* According to the scientific evidence: levels of evidence (modified according to Oxford Centre for evidence-based Medicine (March 2009) and to SIGN 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 from http://www.adipositas-gesellschaft.de/daten/Leitlinie-AGA-S3-2009.pdf), and from the GRADE Working group (published in Britisch Medical Journal 2004;328:1490, Doi:10.1136/ bmj.328.7454.1490, Grading quality of evidence and strength of recommendations, Andrew D Oxman, Informed Choice Research Department, Norwegian Health Services Research Centre, PO Box 7004, St Olavs Plass, 0130 Oslo, Norway)

Table 8: Descriptive results in the areas of activities and participation

Author	Year	Descriptive findings
Lefebvre et al.[34]	1998	Predicting ball flight is more difficult for children with 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 boys with DCD not due to impaired visuo-perceptual or planning processes but due 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 9: Consequences with respect to activities and participation

Author	Year	Consequences
Hay et al. [65]	1998	At the mean age of 12.5 y students with poor self-efficacy were found to have characteristics typical for DCD, but were not identified by teachers as having learning or behavioural disorder.
Smyth et al. [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 et al. [247]	2001	Decreased participation in team sports like football may relate to the ability to maintain posture while carrying out 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 et al. [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, J., et al. [64]	2005a	Regardless of gender, children with DCD had lower self-efficacy towards physical activity and participated in fewer organized and recreational play activities than did children without the disorder. While there were no gender by DCD interactions with self-efficacy and play, girls with DCD had the lowest mean scores of all children (9-14y).
Cairney, J., 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 to their peers as they age
Cairney et al.[248]	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 boys with DCD scored at or below the 20th percentile in respiratory peak flow velocity.
Poulsen et al.[249]	2007	Lower self-appraisals of perceived freedom in leisure and lower overall life satisfaction. Importance in relation to decreased team sport participation (boys 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 boys without DCD; and were lonelier than their well-coordinated counterparts. In those boys 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 et al. [250]	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 et al. [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 had also ADHD).
Summers et al. [60]	2008	Children with DCD needed greater level of structure and assistance - required consistent prompting to complete tasks within allocated time - are 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 5-9 y)
Wang et al. [59]	2009	Pervasive impact of DCD on children's functional performance in daily activities at home and at school (children 6-7 y)

Table 10: Findings in studies on the outcome of DCD (SDDMF) with respect to the level of activities and participation

Author	Year	Outcome
Visser [77]	1998	In normally developing children high velocities in physical growth are negatively related to motor competence, while 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 [90]	1999	A diagnosis of DCD at age 7 years predicts DCD at age 8 years and restricted reading comprehension at age 10 years.
Causgrove [251]	2000	Physical education classes emphasizing a mastery motivational climate may result in higher perceived competence in children with movement difficulties
Christiansen [252]	2000	Everyday activities of boys with DAMP were significantly affected, and they chose to participate in different sports from the control boys, i.e. none participated in team sports.
Rasmussen [93]	2000	In the 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 to ADHD without DCD
Holsti [104]	2002	Early low birth weight (ELBW) children more often have DCD. ELBW with DCD have more arithmetic problems
Cantell [80]	2003	In the educational domain, the adolescents with DCD (age 17) had the lowest WAIS 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 while the intermediate and control groups did not differ
Cousins [253]	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 [254]	2005	For boys, DCD may be a risk factor for overweight/obesity in childhood and early adolescence. For girls, there is no difference in the prevalence of overweight/obesity between children with and without the disorder
Gaines [78]	2007	Young children who are in early intervention programmes for speech/ language delays may have significant co-ordination difficulties; becomes more evident at kindergarten age (more demands in self-care and academic tasks)
Poulsen [249]	2007	Participating in team sports acted as one potential mechanism mediating the inverse relationship between physical coordination ability and loneliness in boys
Kirby [255]	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 subjects 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 also 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 DSA (Disabled Students' Allowance). All students have similar types of support not dependent on their diagnosis.
Cairney [256]	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, 9;0 to 11;11y)

13.5Evidence tables on assessments

Table 11: Questionnaires for assessment of DCD (SDDMF)

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
DCD (SDDMF)Q									
Civetta, L. and Hillier, S.(2008) [257]	Population-based sample 7-8 y from ten mainstream primary schools, metropolitain district participated; no child with neurological or physical impairment 460 children, aged age, school, sex matched control group; 260 parents responded, including 185 acceptances that contained a completed DCDQ; from the respondents, 38 children were identified having DCD or suspect DCD and 40 were selected controls, with 57 of these 78 children participating (73%)	1 / 1b	not examined	not examined	Cronbachs alpha: DCDQ 0.88, item-total correlations -0,28-0,72; M-ABC: 0,75, item total correlations 0,21-0,62	DCDQ: three factors 63,0% (item 11 excluded), M-ABC: three factors 68,2%	DCDQ vs. M-ABC: spearman corr. -.396 for total scores	DCDQ / M-ABC (orig. cut-off): 72% PPV: 46%; cut-off≤5: 69%; PPV 71%	DCDQ / M-ABC: 62% Cut-off≤5: 71%,
Schoemaker, MM. (2006) [108]	1. Population-based sample Children, 4-12 y selected from 14 mainstream schools in the Netherlands 609 children (311 males, 297 females; mean age 7y 8m), 2. Clinical sample 55 children with DCD referred to a rehabilitation clinic control sample of 55 children matched for sex and age (48 males, seven females in each sample, mean age 8y 3m) comparison child was randomly selected from the population-based sample, matched by age (within 6mo) and sex. Mean age for the clinic-referred and control samples was 8 y 3 months (range 4y 2mo–12y 5mo).	1 / 1b	not examined	not examined	Cronbachs alpha: Children> 7y 0.90, children< 8y 0.88	7y: 4 factors plus 1 single factor variance: 70%; item 11 (team sport no loading); age/ gender no effect; <8y: (2 factors plus 3 single factors, variance: 63%; item 11 (team sport no loading); age no effect, sex with effect (female better)	1. low correlation between M-ABC and DCDQ <0.3, 2. high correlation r=-0,65	1. 28,9% PPV: 44%, kappa=0,21 2. 81,6% PPV 85%; kappa=0,65	1. 88,6% 2. 84%

Continued

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
Green D. et al. (2005) [258]	Consecutive, clinical sample 98 children; 75 boys and 23 girls, with an average age of 107.4 months (SD 24.9 momhs). DCDQ (parents): n = 75 M-ABC-C (teachers): n = 75 At the time of the OT assessment, 53 had additional diagnosis (ADHD, PDD, specific learning difficulties)	2 / 2b	not examined	not examined	not examined	not examined	DCDQ vs. OT assessment r=0.298 (if grouped by DCDQ r=0.360), M-ABC C vs. OT assessment r=0.267 (if grouped by M-ABC C 0.162)	OT assessment as reference standard, DCDQ sensitivity 93%, M-ABC C sensitivity 44%	OT assessment as reference standard, DCDQ specificity 19% M-ABC C specificity 74%
Crawford, S. G.. et al. (2001)[259]	Clinical sample total sample 379 children; children with DCD (n= 101, 61 boys, 40 girls) selected matched with 101 non-DCD children (81 boys, 20 girls); control variables: age, ADHD, reading disability	2 / 2b	not examined	not examined	not examined	not examined	not examined	BOTMP (reference standard): M-ABC (index test) 62%. DCDQ: 38%	BOTMP (reference standard) M-ABC (index test) 71%; DCDQ 90%
Wilson, B. N. et al. (2000) [260]	Clinical convenience sample 50 children and adolescents between the ages of 7 y, 1 month and 14 y, 5 months; 26 had known learning or attentional problems or both; 24 had no such problems	2 / 2b	not examined	not examined	not examined	ANOVA between DCD, DCD borderline, no DCD: F=15,1, p<0.0001; no difference for age/ gender	Pearson correlation DCDQ factors with BOTMP components: 0.57-0.66 M-ABC components -0.47	not reported	not reported

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
DCDQ-R									
Tseng, M-H. et al. (2010) [261]	Population-based sample from Grades 1 to 3 (age 6-9y) in 5 of the 141 public elementary schools in the greater Taipei area of Taiwan 1082 questionnaires were included for examining internal consistency and construct validity of the DCDQ-C. Children ages 6.04 to 9.03 y (mean=7.52, SD = 0.82).	1 / 1b	not examined	Subsample of 35 parents: Pearson's coefficient 0.94	Cronbachs alpha 0.84 all item correlation were high except 2 items (if Item 11 and 14 excluded; Cronbachs alpha= 0.89)	3 factor solution (for 15 items) explaining 60.1% of variance after deleting item 11 and 14	not examined	DCDQR (P10) vs. combined reference standard (M-ABC and BOTMP) 73%	DCDQR (P10) vs. combined reference standard (M-ABC and BOTMP) 54%
Wilson, B. N. et al. (2009) [122]	Questionnaires were distributed to 1,899 students in 11 public schools within the four quadrants of the city of Calgary, Alberta, Canada, to obtain a cross-section of the socioeconomic strata in the city. Questionnaires were initially sent between April 2004 and June 2004, with a stamped, self- addressed envelope to facilitate a higher return rate. Following distribution, both a reminder letter and then a reminder card were sent to the parents through the children's teachers. Return rate was only 15 percent, so a second distribution was done in January 2005, also with two reminders. In total, 297 questionnaires were returned (16% return rate) and 287 had complete data (at least 20 of the 24 items completed).	2 / 2b	not examined	not examined	Phase 2: Cronbachs alpha DCDQR (24 items) 0.90. DCDQR (15 items) Internal consistency: 0.89 Item-total correlations .42 to .67 Total score no age/ gender differences Phase 4: Cronbachs alpha 0.94	DCDQ valid for use with both genders; age-specific cutoff scores necessary	DCDQ vs. M-ABC total score -0.55, vs. VMI: -0.42 (ADHD not confounding)	Phase 3: best cutoff ≤53: sensitivity 81% Phase 4: after adjusting scores for age: 84,6%	Phase 3: best cutoff ≤53: specificity 65% Phase 4: after adjusting scores for age: 70,8%

continued

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
Prado, M. S. S. et al. (2009) [123]	Population-based sample, not representative, 15 children with motor coordination problems identified 30 control children matched for age. 5 parents randomly selected from each group completed the questionnaire twice, to examine test-retest reliability. Additional clinical sample: 15 children with motor coordination problems, identified by experienced pediatric occupational therapists. Inclusion criteria included: (a) children receiving physical or occupational therapy for motor coordination problems, (b) ages 5 to 12 y, (c) attending regular schools, and (d) presenting no signs of a medical condition, specific neurological disease or mental disability.	3 / 3b	not examined	ICC 0.97. (5 parents from each group randomly selected to complete the questionnaire twice, 14 days apart)	Cronbachs alpha = 0.92	not examined	not examined	Canadian version to Brasilian version A: 66,6% to 73,3%	Canadian version to Brasilian version A: 83% to 86,6%
Loh, P. R. et al. (2009) [262]	Clinical convenience sample of children with DCD/ADHD Control group: typically developing children in the area of Perth/Australia without obvious neurological history and physical handicap 38 girls and 91 boys aged 9-12 y	2 / 2b	not examined	not examined	not examined	not examined	Spearman correlation between factor scores: up to 0.32, most 0.2-0.3	DCDQR vs. MAND 55%; PPV 52%	DCDQR vs. MAND 74%; NPV 76%
Cairney, J. et al. (2008) [263]	Population-based sample from Southwestern Ontario, Canada All children in each of three schools (first 3 schools answering first after contacting 129 schools) enrolled in grades 4 through 8. 523 children and their parents	2 / 2b	not examined	not examined	Cronbachs alpha 0.94 internal reliability of subscales .81 to .91.	Correlations among subscales .58 to .75; 3-factor model	DCDQR vs. CSAPPA r=.38, subscales r=.41 to .47; Agreement: kappa .18	not examined	not examined

continued

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
M-ABC-Checklist (M-ABC-C)									
Schoemaker, MM (2003) [264]	Population-based sample from the Netherlands 120 children, 6 to 11 y , randomly selected from mainstream schools and clinical sample of 64 children, 6 to 9 y , referred for assessment of their motor functioning.	2 / 2b	not examined	not examined	.96 (total score) (0,83 – 0,90 for section 1 to 4)	F=3,32, p<0.001 (MANOVA), p<0.001 to p<0.002 for differences between sections 1 to 4 7 factors (ball skills with highest loadings) 49% of variance	M-ABC-C vs. test (s. Percentage agreement)	M-ABC-C P5 (P15) vs. M-ABC P5 for P5 65% (P15: 85%) M-ABC-C P5 (P15) vs. M-ABC P15: for P5 62% (P15: 79%)	M-ABC-C P5 (P15) vs. M-ABC P5 for P5 66% (P15 55%) M-ABC-C P5 (P15) vs. M-ABC P15: for P5 66% (P15: 65%)
Junaid, K. et al (2000) [119]	Population-based sample from School District 43 British Columbia, Canada 164 school children from 10 elementary schools in school district final sample: 103 children with mean age of 8 y no children with severe neurological and physical handicaps, severe ehaviour problems, or severe language disorder	2 / 2b	not examined	not examined	not examined	not examined	not specified	M-ABC-C (P15) vs. M-ABC prevalence of DCD 14.3 %, M-ABC-C (P5) 11.1 % PPV 50% at both cutoffs	M-ABC-C (P15) vs. M-ABC specificity 97.8%, M-ABC-C (P5) 98.9% NPV 87,9% (P15) vs 92,1% (P5)
Piek, J. and Edwards, K. (1997) [265]	Population-based sample from the Perth metropolitan area, Australia 171 children initially assessed; 32 children found to have coordination problems compared with 32 control children, matched on age, sex and Verbal IQ	2 / 2b	not examined	not examined	not examined	not examined	not examined	physical education teacher identify more children with DCD than class teachers (classified by M-ABC test); sensitivity of M-ABC-C is 25% vs. 49%	not specified

continued

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity

Wright, H.C. and Sugden, D.A. (1996) [121]	Population-based sample, random selection from Singapore primary school districts M-ABC-C n=427 (218 girls, 209 boys) returned properly and complete; reliability testing in n=120, n=103 returned; n=64 identified as having functional problems, assessed with M-ABC test	1 / 1b	not examined	Pearson correlations from test-retest children (N=103) on the M-ABC-C acc. to age bands: 7y: boys r=0.92; girls r=0.93; 8y boys r= 0.94; girls r=0.50;	not examined	not examined	not examined	M-ABC-C (P15) plus M-ABC test indicates prevalence of 4% M-ABC-C alone (P15): 10,1% (at risk), 6,1% (definite) (64 / 427 children) M-ABC test vs. M-ABC-C: 17/64	not specified
MPC									
Gwynne, B. (2004) [266]	Population-based study, random selection of 7 infant schools in Sydney area, Australia 141 children (5y) Motor Performance Checklist compared against BOTMP	1 / 1b	0,93 (0,79-0,99)	100% (t=0:15; p<0.05); interval: 2 weeks	0,77 (Pearson correlations)	not examined	0,72 (MPC-Bruininks Oseretzky Test Long Form (1978) 0,58 MPC - gross motor subtests; 0,60 MPC - fine motor subtests	83% (MPC at cut-off ≥4); PPV: 72% positive likelihood ratio: 55,3, post-test probability 73%	98% (MPC at cut-off≥4); NPV: 99%
Gwynne, K et al. (1996) [267]	Population-based study, random selection out of 51 schools in the area 123 children (5y) in their first year of school Motor Performance Checklist compared against BOTMP	2 / 2b	not examined	not examined	not examined	not examined	0.64 (Motor performance checklist with BOTMP)	75% (MPC vs. BOTMP), 88% (teacher-parent referrals vs. BOTMP)	95% (MPC vs. BOTMP), 41% (teacher-parent referrals vs. BOTMP)

Other questionnaires

Author (Year)	Study population	Grade/ Oxford Criteria	Interrater reliability	Retest reliability	Internal consistency	Construct Validity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
Teacher estimation of activity form (TEAF)									
Faught, B.E. et al. (2008) [268]	Population-based sample, random selection of 15 of 75 schools from the District School Board of Niagara from Ontario, Canada 502 students in Grade 4 aged 9–11 y evaluated for probable DCD (pDCD) in school using the short form Bruininks–Oseretsky test of motor proficiency (BOTMP– SF), Children's self perceptions of adequacy in and predilection toward physical activity (CSAPPA) scale, participation questionnaire	1 / 1b	not examined	not examined	not examined	Cronbach's alpha for the TEAF .98. TEAF: unifactorial.	TEAF vs. CSAPPA (r=0.45, p=.001), vs. Participation Questionnaire (r=0.25, p=.001) and vs. VO 2 max (r=0.56, p=.001). TEAF vs. BMI (r=-0.25, p=.001) Gender without effect	TEAF score <32 is preferred (sensitivity =.85, CI=.68-.94); cut-point <29, sensitivity .74 (CI=.55-.87)	Test of Gross Motor Development second edition (TGMD-2) score <32: specificity = .46, CI=.42-.51). TEAF score <29: specificity to .62 (CI=.58-.66)
CSAPPA									
Cairney, J.et al. (2007) [107]	Population-based sample, cross-sectional study, grades 4-8 from 5 elementary schools in Ontario, Canada. 590 children BOTMP-SF and Children's self perceptions of adequacy in and predilection toward physical activity (CSAPPA)	2 / 2b	not examined	not examined	not examined	not examined	not examined	Adequacy Subscale: Cut-off =24: 86%; PPV 0,12	Adequacy Subscale: Cut-off =24: 47%; NPV:0,98
Hay, J. et al. (2004) [118]	Convenience sample from a single public elementary school 208 children (121 boys, 87 girls) BOTMP test, CSAPPA scale, Participa- tion Questionnaire, Léger 20-meter Shuttle Run, and body fat using bioelectric impedance	2 / 2b	not examined	not examined	not examined	not examined	not examined	CSAPPA vs. BOTMP-SF: 0.90 (CI = .18) for boys (cutoff<47), 0.88 (CI = .05) for girls (cutoff 53)	CSAPPA vs. BOTMP-SF: 0.89 (CI = .22) for boys (cutoff<47), 0.75 (CI = .09) for girls (cutoff 53)

Table 12: Studies on the Movement Assessment Battery for Children (M-ABC)

a) Description of the studies

	Primary Author	Year	Grade / Oxford	Population	Number of participants	Age	Procedure/ Protocol/ Interval
1	Chow SM., Henderson SE. [27]	2003	1 / 1b-2b	subsample of representative sample of Chinese preschool children	n=138 out of 255; n=79 (41 girls, 38 boys) for interrater reliability, n=75 (37 girls, 38 boys) for retest reliability	4 - 6y	to examine the reliability (interrater and retest, 2 to 3 weeks appart) of the M-ABC, age band 1 in a sample of Chinese children
2	VanWaelvelde, H. - DeWeerdt, W. - DeCock, P. - Smits-Engelsman, B.C.M. [165]	2004	2 / 2b	Screening by ball catching test: 1214 children from mainstream schools, 298 children from school of special education, 205 children in non residential rehabilitation centers; 5th perc. defined as poor ball-catchers, 90 children (without organic and mental problems)	90 poor ball-catchers (50 boys, 40 girls), 43 controls (29 boys, 14 girls)	7 - 9 y	to assess the concurrent validity of M-ABC total score and some item scoress of the second and third age band of the M-ABC. Further, ball-catching test and 2 tasks measuring dynamic balance (from KTK);
3	Croce RV., Horvat M., McCarthy E.[269]	2001	2 / 2b	convenicence sample from 2 elementary schools	n=106; 39 girls, 67 boys	5 - 12 y (4 age bands: 5-6y n=20, 7-8y n=20, 9-10 n=46, 11-12, n=20)	examining the test-retest-reliability and the concurrent valitiy of the M-ABC (age band 4-6y) with the BOTMP-SF/LF
4	Van Waelvelde H., Peersman W., Lenoir M., Smits Engelsman BC. [28]	2007	2 / 2b	School sample selected by 13 teachers from mainstream schools (to select 3 children with worst motor skills without known handicap in their classes) in Belgium	39 children selected, 37 children with informed consent; 33 children participated in all 3 measurement points (24 boys, 9 girls)	4;0 - 5;11y	to examine the test-retest-reliability by assessing the children 3 times (3 weeks apart) with the M-ABC
5	Smits-Engelman, BCM. [163]	1998	2 / 2b	randomised population-based sample vs. out-patient sample; Normal children vs. children referred for assessment of their motor functioning (Dutch children)	134 (normal children), 74 (out-patients)	1. 5 - 13 y, 55% boys, 45% girls, 2. 5-12y, 62% boys, 38% girls	M-ABC test vs. KTK test; each to half of the groups
6	Rösblad, B. [270]	1998	2 / 2b	population based sample; matched pairs transcultural comparison; normal children (Swedish vs. US standardization sample)	2x60	6 y (73 - 83mths; mean 66 mths)	M-ABC (age band 1): 8 tasks (3 hand use, 2 catching/throwing, 3 balance)
7	Leemrijse C., Meijer OG., Vermeer A., Lambregts B., Ader HJ. [271]	1999	2 / 2b	Clinical convenience sample of children recruited from 2 schools for special education and one schuool for children who are chronically ill	23; 3 girls, 20 boys	6-8y;	to examine the change measured by the M-ABC (3 measurements two to three weeks apart)

	Primary Author	Year	Grade / Oxford	Population	Number of participants	Age	Procedure/ Protocol/ Interval

8	High, J., Gough, A., Pennington, D., Wright, C. [272]	2000	3b	mainstream schoolboys, medical professionals described them as clumsy or as having coordination difficulties, but with no overt additional physical handicap	14 boys	5 - 11 y	Southern California Sensory Integraton Tests (SCSIT) and Perceptuo-Motor Battery (PMB) consisting of M-ABC and TAK (tactile perceptual tests)
9	Chow SM., Henderson SE., Barnett AL. [137]	2001	1 / 1b-2b	Representative sample of Chinese preschool children compared to subsample of a US representative sample of children	n=255 Chinese children ("roughly half girls, half boys) compared to 493 out of 1234;	4-6y	to examine the cross-cultural differences between a Chinese and US samples on M-ABC
10	Sugden, DA., Chambers, ME[196]	2007	3b	1. convenience sample from local schools (teachers identifying children with mov. difficulties) 2. all identified children were assessed with Movement ABC, children who scored in the lowest 15% were included	originally n = 31 (m 22, f 9), at the end of project n = 26 (18 m, 8 f)	originally 8.04y (7.01-9.06 y), at the end of project 11.5y (10.09-13y)	To examine the change and stability of profiles of children with DCD over a time period of 4 y, which included two periods of intervention by teachers and parents. Profiles involved core motor defining feature of DCD + characteristics of self-esteem and educational progress; overall project was divided into two parts: 1st part intervention through teachers and parents (two seven week periods), it examined effect of intervention; second part monitored 26 children over 2 y with SATs, B/Steem, Movement ABC Test and teacher/parent interviews
11	Junaid KA., Fellowes S. [273]	2006	1 / 1b-2b	random selection of children from a school district in British Columbia, Canada	n=103; 43 girls, 60 boys	7 - 8 y	examining the gender effect on M-ABC scorings
12	Van Waelvelde H., Peersman W., Lenoir M., Engelsman BC. [274]	2007	2 / 2b	clinical convenience sample from a Center of Developmental Disabilities and a Center for Ambulant Rehabilitation in Flanders	n=31 (4 girls, 27, boys	4:0 - 5;11y; m=4;11y, SD 6mths	examining the concurrent valitiy of the M-ABC (age band 4-6y) with the Peabody Developmental Motor Scales (PDMS)
13	Livesey D., Coleman R., Piek J. [275]	2007	1 / 1b-2b	representative sample of children without known impairments in Australian cities(preschools in Sydney /Perth, random cross-section of Socio-Economic Index for Areas) compared to US standardisation sample;	128 children at 3y (71 boys and 57 girls); 149 children at 4y (82 boys and 67 girls); 237 children at 5y (127 boys and 110 girls)	3;0-5:11y	to explore the difference of performance M-ABC of Australian children and US children at age 4 to 5y (validity of norms)
14	Smits-Engelsman BC, Fiers MJ, Henderson SE, Henderson L. [276]	2008	2 / 2b	Convenience sample of 9 children with movement difficulties in Netherlands	9 children (3 girls, 6 boys); 131 therapists (120 women, 11 men)	4-12y (one child per year)	in order to determin the interrater reliability children were assessed by videotaped sessions of the M-ABC by therapists
15	Van Waelvelde H., Peersman W., Lenoir M., Smits-Engelsman BC. [277]	2008	1 / 1b-2b	quasi-representative sample of children without known impairments in Flanders (44 regular schools from different areas) compared to US standardisation sample; both sample comparable concerning gender, geographic region, ethnic origin	267 children (141 boys, 126 girls) (4y), 239 children (5y) (119 boys, 120 girls)	4;0-5;11y	to explore the difference of performance on M-ABC of Flemish children and US children at age 4 to 5y (validity of norms)

16	Chen, YW. [166]	2009	1 / 1b-2b	Population based sample with systematic recruitment of children receiving CBCL-C and DCD-Q as screening instruments (total sample examined of children returning the CBCL-C and agreed for motor testing)	N=270, DCDQ < 10% sample: n=144, DCDQ > 25% sample: n=126	mean 7,7y (SD 0.81), range 6;3 to 10;11 y	to examine consistency and agreement between motor test (M-ABC, BOTMP), to examine behavioural characteristics of children being diagnosed as DCD in both motor tests
17	Cairney, J.; Hay, J. et al. [167]	2009	3b	Population-based study identifying children with probable DCD (by BOTMP-SF). Random selection of subgroup (below 6th perc) (children in Grade 4 within the Public school system in a large region of southern Ontario); very small control group (n=3)	The BOTMP-SF was administered to N=2058 children. 128 children <6th percentile found, 24 children were randomly selected for further assessments; 6 controls	DCD: 12 boys, 12 girls; M = 11,2y (SD 0,6); controls: 5 boys, 1 female M= 11,1 (SD 0,7)	Data collection occured during the school years from 2005 to 2007. 75 schools that agreed to participate. The BOTMP-SF was administered by trained research assistants to 2058 children. 24 of 128 children scoring below the sixth percentile were randomly selected for further assessment by OT's using the M-ABC and the Kaufman Brief Intelligence Test: 24 probable cases and six controls
18	Engel-Yeger B., Rosenblum S., Josman N. [278]	2010	2 / 2b	Convenience sample of typically developing children in Israel (all children above 15th perc of the M-ABC, no mental or physical handicap	249 children, (209 boys, 40 girls)	4;1-12;8y (M=8,27, SD 2,34)	to examine the construct validity of the M-ABC in a sample of typically developing children
19	Tan, S.K, Parker, HE., Larkin, D. [164]	2001	3b	convenience sample: referred group for motor impairment vs. recruited group from a city 1. referral for therapy, M-ABC<15%; matched pairs 26 children from referral group vs. 2. recruited group (Australian children)	2x26 (referral groups vs. matched controls; drop out analysis reported	1. 11 girls (mean 83,4, SD 22mths), 15 boys (mean 78,7, SD 17) 2. 11 girls (mean 84,5, SD 21), 15 boys (mean 79,5, SD 17)	To examine the concurrent validity of the M-ABC test (reference standard) vs. BOTMP-SF and MAND

Continued

b) Results of the studies (M-ABC): test criteria, descriptive results

	Primary Author	Year	Interrater-Reliability	Test-Retest-Reliability	Reliability: Internal consistency	Construct and Criterion validity	Concurrent Validity (index vs. Reference test)	Sensitivity / positive predictive value (PPV)	Specificity / negative predictive value (NPV)
1	Chow SM., Henderson SE.	2003	0.96 (subtests: 0.74 to 1.00)	0.77 (subtests: 0.64 to 0.86; age groups 0.70 to 0.77)	not examined		not examined	75 / 75 children were correctly classified by 2 examiners (<5 th perc, 6 children)	not examined
2	VanWaelvelde, H. - DeWeerdt, W. - DeCock, P. - Smits-Engelsman, B.C.M.	2004	ball catching test 0.99	ball catching test 0.91	not examined	not examined	M-ABC total vs. Ball catching: 7-8y -0.72, 9y -0.68 (M-ABC ball skills score -0.72 / - 0.53); vs. KTK jump: 7-8y -0.76, 9y -0.69 (M-ABC balance score -0.70 / - 0.65); vs. KTK beam: 7-8y -0.72, 9y -0.58 (M-ABC balance score -0.68 / - 0.69)	not examined	not examined
3	Croce RV., Horvat M., McCarthy E	2001	not examined	0.95 (0.92-0.98 in different age bands)	not examined	not examined	total scores: M-ABC vs. BOTMP-LF 0.76 (0.70-0.90); vs. BOTMP-SF 0.71 (0.60-0.90)	not examined	not examined
4	Van Waelvelde H., Peersman W., Lenoir M., Smits Engelsman BC.	2007	not examined	ICC: total score 0.88 (CI: 0.79-0.93), dexterity subscore 0.75, ballskills subscore 0.45, balance subscore 0.82. Item level: 0.14 (rolling a ball into a goal) to 0.81 (jump over chord) kappa=0.72 (CI 0.52-0.92)	not examined	not examined	not examined	not examined	not examined

5	Smits-Engelman, BCM	1998	not examined	not examined		not examined	1. M-ABC total / KTK total: 0,62; subscores correlations < 0,5 2.M-ABC total / KTK total: 0,65; subscores correlations <0.6	1. M-ABC score distribution in controls / standardisation replicated < 15th percentile, 16%, < 50th perc. 50% of children (similar to American norms); KTK: motor performance <15th percentile: 29%, <50th perc. 68% of children	2. Distribution of test results in clinical sample: M-ABC score distribution / standardisation replicated < 15th percentile, 59%, < 50th perc. 84% of children; KTK: motor performance <15th percentile: 68%, <50th perc. 85% of children
6	Rösblad, B	1998	not examined	not examined	not examined	not examined	not examined	1 out of 8 between group comparisons significant (p<0.002) (rolling ball into goal better in Swedisch sample); within group comparison (rural vs. urban) not significant	not examined
7	Leemrijse C., Meijer OG., Vermeer A., Lambregts B., Ader HJ.	1999	not examined	not examined	not examined	not examined	not examined	not examined	not examined
8	High, J., Gough, A., Pennington, D., Wright, C.	2000	not examined	not examined	not examined	The individual tests within the PMB were considered for content validity and matched with the functional domains assessed by the SCSIT	SCSIT vs. M-ABC subtests: imitation of postures: r=0.06, standing balance Eyes open (n=13): r=0.10; bilateral motor coordination (n=12): r=-0.26; SCSIT vs. PMB (M-ABC + TAK): r=0.57 / 0.67	not examined	not examined

9	Chow SM., Henderson SE., Barnett AL.	2001	not examined	not examined	not examined	1. no effect of area or parental education within Chinese sample, 2. Chinese children better in manual dexterity tasks and in balance tasks, US children better in tasks involving the projection and reception of a moving object. Country x gender effect: Chinese girls better the US girls, boy no differences in balance tasks; Country by age effect: younger Chinese children were better than US children in drawing trail	not examined	not examined	not examined
10	Sugden, DA., Chambers, ME	2006	not examined	not examined	not examined	not examined	not examined	not examined	not examined
11	Junaid KA., Fellowes S.	2006	not examined	not examined	not examined	not examined	not examined	not examined	not examined
12	van Waelvelde H., Peersman W., Lenoir M., Engelsman BC.	2007	not examined	not examined	not examined	not examined	not examined	22 / 31 children were similarily classified in M-ABC and PDMS (68% agreement); kappa .29 (CI: 0.15-0.43)	not examined
13	Livesey D., Coleman R., Piek J.	2007	not examined	not examined	not examined	strong age effects in all items (F=12 to 119), gender effects in 5 of 9 items; differences between Australian sample and US standardisation sample (urban area) were only in two items	not examined	not examined	not examined
14	Smits-Engelsman BC, Fiers MJ, Henderson SE, Henderson L.	2008	Kappa=0.95 to 1.00 (for the 9 videos) mean differences of scores: 1,1 (SD 0,7) to 2,9 (SD 2,3)	not examined	not examined	not examined	not examined	not examined	not examined

15	Van Waelvelde H., Peersman W., Lenoir M., Smits-Engelsman BC.	2008	not examined	not examined	not examined	Children with 5y better than 4y olds (all tasks, F=20,4 (total score), F=38.9 (balance subtest)), no gender effects. Age effects: F=6,96 (Total score), F=10,28 (Manual dexterity), F=5,44 (Ball skills), F=10.07 (Balance); On Manual dexterity: 4-6age band scored better than 9-10age band that scored worse than 11-12 age band; on Balance: 4-6age band and 7-8 age band scored better than 11-12age band (static balance item); on ball skills boys performed much better than girls (F=21.39), girls were better in balance (F=4.15); Total score (F=8,24, (only 5y)), Balance subscore (F=7,31 (only 5y) and Manual dexterity subscore better in Flemish children (F=8,37 (4y), F=7,39 (5y) than in US sample	not examined	not examined	not examined

16	Chen, YW	2009	not examined	not examined	not examined	not examined	not examined	BOTMF / M-ABC identifying 27 / 61, M-ABC / BOTMF identifying 27 / 41 possible DCD M-ABC 15th vs. BOTMP cutoff 40: 61 recognised by M-ABC, 41 recognised by BOTMP, 27 recognised by both (total sample n=270)	BOTMF / M-ABC identifying no DCD: 195 / 209, M-ABC / BOTMF identifying 195 / 229 possible DCD
17	Cairney, J.; Hay, J. et al.	2009	not examined	not examined	not examined	not examined	not examined	BOTMP-SF: M-ABC (15th perc.) 21 / 24 children identified, M-ABC (5th perc.) 15 /24 identified; PPV: BOTMP-SF vs. M-ABC (15th perc.) 0.88; vs. M-ABC (5th perc.) 0.63	all unaffected controls recognized (100%) (BOTMF > 6th perc) were > 15th perc of the M-ABC

18	Engel-Yeger B., Rosenblum S., Josman N.	2010	not examined	not examined	not examined	Age effects: F=6,96 (Total score), F=10,28 (Manual dexterity), F=5,44 (Ball skills), F=10.07 (Balance); On Manual dexterity: 4-6age band scored better than 9-10age band that scored worse than 11-12 age band; on Balance: 4-6age band and 7-8 age band scored better than 11-12age band (static balance item) on ball skills boys performed much better than girls (F=21.39), girls were better in balance (F=4.15); Socioeconomic level correlated with manual dexterity (r=0.39) on ball skills Israeli groups scored signif. Lower than American references.	not examined	not examined	not examined
19	Tan SK., Parker HE., Larkin D.	2001	not examined	not examined	not examined	not examined	M-ABC – BOTMF 0.84; M-ABC-MAND: 0.88; BOTMF-MAND: 0.86	BOTMF: 31% Pos. Predictive value: 100% MAND: 81% PPV: 91% MAND-BOTMF: overall agreement: 71%, only 35% of the MI (M-ABC 15th) were recognised in MAND and BOTMF	BOTMF: 100% Neg. predictive value: 59% MAND: 92% NPV: 83%

Table 13: Results on the M-ABC: test criteria, results from test manuals

	Authors	Year	Population	Participants	Age	Procedure/ Protocol/ Interval
20	Henderson, S.E., Sugden, D.A., Barnett, A. M-ABC2 (British Test manual)	2007	Population based study (British sample for standardisation)	N=1172, 606 girls, 566 boys	3;0-16;11	Revision of age bands and some items. Collection of UK norms. Examination of validity and inter-rater and test-retest reliability
21	Petermann, F. M-ABC2 (German Test manual)	2008	Population based study (German sample for standardisation)	N=634; 308 girls, 326 boys	4;0-10;11	To examine the reliability of the M-ABC2 and elicit standardisation values for German test version
22	Smits-Engelsman, B. M-ABC2 (Dutch/ Flemish Test manual)	2010	Population based study (Dutch sample for standardisation)	N=3230 1636 girls 1594 boys	3;0- 16,11	To examine the validity (construct, concurrent), test-retest reliability and measurement error of the M-ABC2 and elicit standardisation values for Dutch test version
23	Soppelsa, R., Albaret, J.-M. (M-ABC (not M-ABC2), French Test manual)	2004	Population based study (French sample for standardisation)	N = 668; 326 girls, 342 boys	4;0-12;11	To examine the reliability of the M-ABC and elicit standardisation values for French test version

Results of the test manuals / M-ABC

	Authors	Year	Interrater-Reliability	Test-Retest-Reliability	Reliability: Internal consistency	Construct and Criterionvalidity	Concurrent Validity (index vs. reference)	Sensitivity	Specificity
20	Henderson, S.E., Sugden, D.A., Barnett, A. [125]	2007	.92 to 1.00 for seven tests of the M-ABC2	r=.73 to .84 for component scores and .80 for total scores.	not examined	Intercorrelations between subscales 0.25 to 0.36; correlations with total score: 0.65-0.76	not examined	not examined	not examined
21	Petermann, F. [279]	2008 (German Test Manual)	.92 to 1.00 for seven tests of the M-ABC2 (same as reported in British test manual)	r=.62 to .92 for 6 tests of the M-ABC2, one test . 06 (because of ceiling effect); Subscales: .73 to .84	not examined	Intercorrelations between subscales 0.25 to 0.36; correlations with total score: 0.65-0.76 as reported in British test manual	not examined	not examined	not examined
22	Smits-Engelsman, B. [138]	2010	Total score 0.98	For 3 y total score .94 For components score ICC's varied between . 67 and .85 Total score for group ADHD and ASS 0.98	Cronbach's alpha ranges from .70 through .87.	Changes with age Differences normal children vs. groups expected to have lower motor performance. Correlations component scores with total score: 0.65-0.76 in norm sample 3 factor structure confirmed in mixed sample of 202 normal children and 139 children with developmental problems	Comparison with different motor tests: correlations BSID .62 KTK .62 BOTMP .58	Compared to PDMS sensitivity . 67 Compared to BOTMP2 . 57 (in standardisation sample and cut off based on samples of different countries)	Compared to PDMS specificity . 96 Compared to BOTMP2 .96 (in standardisation sample and cut off based on samples of different countries)
23	Soppelsa, R., Albaret, J.-M. [280]	2004	Manual dexterity: r=. 976, Ball skills: r=. 995, Balance: r=.981, Total score: r=.987; no differences between raters: 74% difference max. of 1 point: 89%	Manual dexterity: p=.009 (significant improvement) Ball skills: no pre-post differences Balance: no pre-post differences Total score : p<. 05 Increase in retest for manual dexterity (r=.65), particularly for item 2. No differences for other subscales.	not examined	not examined	M-ABC vs. Charlop-Atwell scale of motor coordination r = -.32 (N=50; 4-6 y); M-ABC vs. Lincoln-Oseretsky Motor Development Scale = -. 40 (N=19; 7-12y)	not examined	not examined

13.6Evidence tables on interventions

Table 14: Evidence table on interventions (Studies with GRADE level 3 in greyish)

Author Year	Study Number of patients (n=..)/ studies	Characteristics	Intervention and control	Results	Level of Evidence (GRADE), PEDro scores (../10)
Meta-analysis / systematic reviews					
Pless M, Carlsson M. 2000[193]	Meta-Analysis 13 studies	DCD or motor problems consistent with DCD, experimental designs with at least 1 control group or a single subject design, reported effects of motor skill interventions, reported means and standard deviations for experimental and control group available in study	Category: task-oriented approaches, process-oriented approaches. Task-oriented are: Specific skills approach (task specific instructions, knowledge based approach, effort-centred approach or cognitive-affective approach) Process-oriented are: General abilities approach (NDT/PMT) – SIT approach (SIT/KT)	Task-oriented approach and specially specific skills approach in a group or at home, 5 y and older with best efficacy	1
Hillier S. 2007[185]	31 studies (LOE I-III) incl: children with DCD (n=1105) according to DSM-IV	All studies included being found; all type of intervention, no pharmatology/surgical. Search date 1970-2004.	CATEGORY: task-oriented approaches, process-oriented approaches Specific skills approach like CO-OP, NTT. Psychomotor training Traditional, Process Oriented SIT or SI, KT KT/SIT Spatial training Guided teacher/ parent, Home Exercise, Individual tutoring,. Frequency not researched/ reported.	Intervention for children with DCD is strongly supported, but it may be that generic attributes account for the effectiveness more than specific content. Most commonly investigated approaches: PMT (9x) and SIT (7x), followed by KT (4x). Strong evidence: intervention better than no intervention. 9/8 positive effect for PMT, 6/7 positive for SIT, PT and mastery concepts = strong evidence that these approaches are effective for children with DCD. KT 4/4 positive effects (only 1 RCT) = moderate evidence that approach is effective.	1

Original papers by first author

Allen S. 1995[214]	A pilot study. N=5	Mean age 7 y but children vary between 5 - 11 y . Scored pre- and post test with the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). No other diagnosis or neurological problems, IQ>85, no previous occupational therapy (OT), no behavioural problems.	Category: process-oriented approach 1 hour 1 p/wk, occupational based therapy, activities were oriented towards tactile, vestibular or proprioceptive input, based on Ayres model of sensory integration. Positive aspects were reinforced to encourage the development of self-esteem. No control group.	Child one deteriorated in both fine and gross motor skills, child 5 deteriorated in upper limb function. All other children improved in all areas, most notably in gross motor function.	3 (3/10)
Alloway TP. 2008[281]	A pre post pilot study. All children had learning disabilities. N=20 N=10 with motor difficulties and N=10 suspected (with less severe) signs of motor difficulties. There was an equal mix of these children over the intervention and control group.	Children with (suspected) DCD (55% boys, mean age 7.3y) and with deficits in learning and motor skills Half the intervention groups was suspected and half DCD. (based on MABC-Checklist)	Category: process-oriented-(body function) and some aspects task-oriented approach Daily program of one hour sessions in school for 13 weeks consisting of 10 minutes Brain Gym followed by fine motor movement, balance exercises and gross motor coordination activities. Activities were progressed when the whole group successfully achieved the task.	Improvement for intervention and control group across memory composite and learning measures. Interaction between memory scores and testing times was significant. For the intervention group motor skills improved and visuospatial working memory improved significantly from pre to post-test.	2 (5/10)
Case-Smith J. 1996[282]	A clinical trial. N=26	Children 17M/9F from 4y to 6y with mean age 4y8mo with developmental delays and medical conditions such as spastic di-paresis cerebral palsy.	Category: some aspects of task-oriented approach Occupational therapy was given weekly during 30-45 minutes for one school year in the classroom and according to an individualized education plan and comprised activities on increasing in-hand manipulation, use of tools and eye-hand coordination, consulting with the teacher and other team members and sensorimotor and fine motor activities in small groups.	Intervention resulted in a significant progress in all measures of motor skills, except grasping strength. Improvements in motor accuracy were statistically and clinically significant.	3 (4/10)
Cohn ES. 2000[217]	Collective case study approach of interviews of 16 parents	Children with some type of sensory integration dysfunction	Category: process-oriented approach occupational therapy with a SIT approach for at least 32 one-hour sessions	Reconstruction of the self-worth, children used newfound abilities to enhance participation in activities, organized and non-organized as well as personal care activities. Parent's understood their children's behaviour better which resulted in being able to support and advocate their children.	3 (1/10)

Cosper S. 2009[283]	Clinical trial N=12	10 children with combined DCD/ADHD and two children with combined ADHD/PDD, age 6.5 tot 13.5 y, 10M/2F	Category: other approach* interactive metronome training individually over a fifteen-week period, once a week for one hour.	42-75% of the children improved on the Gordon diagnostic System for attention and 50-83% of the children improved on the Bruininks-Oseretsky test of motor proficiency-Short Form for motor-control and coordination.	3 (0/10)
Davidson, Williams 2008[215]	Pre-post no control group N=37	DCD < 15th MABC, 12 months follow up Age not known, Gender not known	C; process-oriented approach All children same treatment : combined SIT and PMT for 10 weeks followed by home program	Significant improvements were detected only on total movement ABC but actual change was relative1y sma1l. Authors conclude that this type of l0-week occupational therapy intervention does not have any significant clinical benefit for children with a diagnosis of DCD at 12-month follow.	3 (2/10)
Flapper BCT, Houwer S, Schoemaker MM. 2006[229]	Controlled Trial N=12 intervention N=12 controls	ADHD+DCD, mean age 9y8m, 11M/1F. M-ABC <15th percentile, MPH sensitive. Matched controls	Category: other approach* MPH daily during 4 w C: no intervention	MPH improves manual dexterity and quality of handwriting	2 (6/10)
Flapper BCT, Schoemaker MM. 2008[284]	Controlled Trial N=23	ADHD+DCD, age range (7.0-10.8y), 21M/2F. Mean IQ 94, M-ABC < 5th percentile. Matched controls	Category: other approach* MPH daily during 4 w C: no intervention	MPH improves ADHD ratings, M-ABC scores, HRQOL. Additional physiotherapy needed in 50% of children	2 (5/10)
Green D. 2008[186]	Stratified RCT Cross-over N=43	DCD, age range (5.0-10.8y), 37M/6F. Mainstream education. M-ABC 5-15th percentile	Category: task-oriented approach CO-OP 20x 1h p/w C: no intervention	Significant improvements in motor skills for treated groups. Subtype of DCD indicates no difference on intervention results due to CO-OP. Progress in motor skills following CO-OP is unrelated to initial severity or subtype	2 (8/10)
Jongmans MJ. 2003 (1) [202]	Quasi-experimental. N=14 Children attending Dutch mainstream schools.	Intervention group N=7 6M/1F mean age 7,92 y. Score on the BHK dysgraphic. Control group N=7 6M/1F mean age 8,63 y. Normal score on the BHK.	Category: task-oriented approach 18 individual lessons by remedial teacher 2 x p/w, 30 min. during 3months. Pictograms based on NTT indicating attention to posture/ paper place/pen grip/proportion letters/slope/form/space/tempo. End each session: write/draw illustrated short story.	The task oriented self instruction method has shown a positive effect on the quality of handwriting of children with poor handwriting quality. The average gain in scores for speed did not differ significantly between experimental and control groups.	2 (5/10)
Jongmans MJ. 2003 (2) [202]	Quasi-experimental. N=60 Children attended 2 Dutch special education schools.	Dysgraphic N=24, Intervention: N=18 14M/ 4F, mean age=8,94y. No intervention N=6 6M mean age=9,67y. Normal writer N=36, Intervention N=18 9M/9F mean age=10,94y. No intervention N=18 8M/10F mean age =9,94y.	Category: task-oriented approach 6 months 2 p/wk 30 min. Group intervention by teachers instructed to teach motor learning principles based on NTT; children taught to teach themselves. Strict letter form instruction, self-feedback or peer review.	Training of children with poor handwriting shows improvement of the quality of their handwriting. Children in special education schools scoring normal on the BHK with no intervention deteriorated in their performance after 6 months at the post-test. The self-instruction method used in both studies seems to have benefited the quality of handwriting and for children in special education schools to prevent them from dropping their standard after 6 months.	2 (5/10)

Hall A. 2005[285]	RCT n=117	DCD not receiving treatment	half placebo half fatty acids, 3 month follow up	Omega 3 fatty acids and omega 6 fatty did not improve motor function but did improve reading , spelling and symptoms of ADHD at 3 months	2 (9/10)
Klein S. 2008[286]	A pilot study. N=6	5M/1F, mean age 9y. Range = 7y+9mo - 10y +4mo. Population: DCD based on DSM-lV. Children were included also using the fine motor subscale of BOTMP and VMI-lV	Category: task-oriented approach 1. development of dexterity + isolated finger movement abilities 2. typing program for children 6 y and older 3. generalization of keyboarding skills + introduction to computer use and word processing skills. 5 days every week, one hour treatment for 2 weeks group training, with pre- and post measurements of letters per minute printing + typing. No control group.	Keyboarding speed was slower than printing/ handwriting speed for all children except for 1. Printing/handwriting increased for 4 children and decreased in 2. The speed of using the keyboard improved in 5 children. In day #10 letters per minute on the keyboard were on all children higher than at post-test	3 (5/10)
Leemrijse C. 2000[216]	A cross-over study. N=6 Children underwent both interventions, 3 children first underwent LBD followed by SIT, 3 children first underwent SI, followed by LBD.	DCD 5M/1F, age ranged from 6.0 to 8.1y	Category: some aspects of task-oriented approach vs. process-oriented approach LBD is individualised therapy addressed to specific problems of the child and uses different musical instruments and materials. LBD is divided into a preparation phase, a main learning phase and a period of variations and was given for 12-18 sessions SIT is a non-cognitive movement-based therapy developed by Ayres and was given for 12 -18 sessions	No significant effect of treatment order was found. More improvement on the M-ABC and the visual analogue scales (VAS) were found after both treatment periods. There were more advantages of LBD over SIT	2 (7/10)
McWilliams S. 2005[231]	Clinical trial N=12	DCD according to DSM-lV <15th percentile with three children >15th percentile 11M/1F, age range between 6y3mo and 11y1mo Population: DCD	Category: task-oriented approach group therapy consisting of motor based activities including hockey skills, volleyball, balloon and obstacle courses. Sessions were given once weekly over a period of six to eight weeks for one to one an a half hour.	Methodological problems limit significance of results. Group therapy had a positive effect in the majority of cases on the children's self-esteem, at least in the short term.	2 (5/10)
Miller LT. 2001[287]	Pilot trial N=10 intervention CO-OP N=10 intervention CTA	DCD, 10 children receiving CO-OP = 7M/ 3F, mean age 8.90y, 10 children receiving CTA 7M/3F, mean age 9.20y	Category: task-oriented approach vs. process-oriented approach CO-OP and CTA were given individually according to an intervention protocol during ten sessions of 50 minutes. During CO-OP children learned the goal-plan-do-check strategy. Main treatment goals: writing, printing, bicycling, keyboarding and organization. During CTA neuromuscular, multi-sensory and biomechanical approaches were used. Treatment goals were set by the therapist.	The improvement with CO-OP is greater than CTA for performance and satisfaction felt by child, on motor behaviour observed by physical therapist and on occupational competence reported by parents. Improvement of the child's confidence in motor tasks and maintaining motor goals lasts, according to parents, for at least 7.5-13 months.	2 (4/10)

Niemeijer AS. 2003[204]	A study to develop a motor teaching principle taxonomy (MTPT) in order to investigate what teaching principles therapists trained in NTT, use in daily practice. N=23	18M/5F, mean age 7y6mo (SD1.1) referred to physiotherapy because of motor coordination problems. Inclusion criteria were: M-ABC score below 15th percentile, if individual physiotherapy was needed, all criteria for DCD were met attending regular elementary school and no history of physiotherapy.	Category: task-oriented approach 13 therapists were videotaped during one NTT intervention after the child had already underwent at least 6 therapy sessions. The MTPT contains three categories: giving instruction, sharing knowledge and providing or asking feedback which is subdivided into 20 actions.	During NTT sessions therapists differ in their tutoring styles and used "giving instruction" most frequently which indicates that children practise a lot during treatment sessions. Therapists explained the difficulty of the task more often to children with lower scores on the Movement Assessment Battery for Children (M-ABC) and communicated more often what went wrong in movement pattern and executions to children with low scores on the Test of Gross Motor Development second edition (TGMD-2). This indicates that the choice for applying these principles depends on the children's performance levels.	3 (3/10)
Niemeijer AS. 2006[288]	Pilot study. N=19	Children had an IQ within normal range and met the four criteria of DCD in the DSM-IV, were recently referred for physical therapy and had no history of physical therapy. They had a score on the M-ABC at or below the 15th percentile.	Category: task-oriented approach NTT once weekly 30 minutes for nine weeks.	A significant improvement between mean pre- and post test scores on the M-ABC and TGMD-2 scores were found. Four principles of the MTPT were associated with improved performance on the TGMD-2 namely: “giving clues”, “explaining why”, “providing rhythm” and “asking about understanding”. Two principles were associated with improvement on the M-ABC namely “adjusting body position” and “explaining why”.	3 (4/10)
Niemeijer AS. 2007[192]	Controlled trial. N=26 intervention N=13 no intervention.	DCD, 26 children who received intervention 20M/6F, mean age 7y2mo 13 children who received no intervention 10M/3F, mean age 7y2mo	Category: task-oriented approach During nine treatment sessions of NTT 30 minutes functional exercises were trained following the major categories of the M-ABC (balance, ball skills, manual dexterity) and the TGMD-2 (locomotor like running and horizontal jumping and object control like striking, bouncing and throwing)	The treatment group improved significantly on the M-ABC, the M-ABC score of the control group stayed stable. The treatment group improved on the TGMD-2 scores, while these scores deteriorated in the control group. Clinically significant improvements occurred more frequently in subtests that measured comparable motor performance as in tasks that were trained. The TGMD-2 results showed that severity could be predictive for treatment success. Older children improved more on the TGMD-2.	2 (6/10)

Parush S. 1997[289]	A randomized study. N= 53	Children with perceptual-motor dysfunction in Israel. Gross motor group n=27 (20M/7F, mean age 5y7mo), fine motor group n=26 (20M/6F, mean age 5y7mo)	Category: other approach comparison of a gross motor, large space treatment setting with a fine motor, restricted space treatment setting. Gross perceptual motor treatment: group treatment in a spacious outdoor area which was equipped with toys and devices like balls, swings and a trampoline. Children used activities like climbing, crawling and balance activities. Fine perceptual motor treatment took place in a quiet room where children sat at the same table and performed activities addressed to visual motor integration and fine motor needs such as puzzles, pegboards, drawing and scissors tasks. Both treatments were given for 7 months, 1 ½ hour sessions once a week.	Subjects in both treatment groups improved as a result of intervention, as demonstrated by gains in post-tests scores on measures of balance, postural and constructional praxis, visual perception, visual motor integration, body image, following spatial directions and finger dexterity. The postural praxis post-test revealed lower scores among the fine motor group.	2 (7/10)
Peens A. 2008[189]	A randomized clinical trial. N=58	7 to 9 y old children with DCD, 36M/22F divided into 4 groups: Motor based intervention (MIV) group n=20, psychological program (SC) group n=10, psycho-motor intervention (P-MI) group n=11, and control group n= 17	Category: other approaches MIV: twice weekly sessions of 30 minutes for 8 weeks. Each session started with fundamental locomotor activities combined with activities for improvement of vestibular stimulation and kinesthesis. The rest of the content was divided into ball skills, balance skills, fine motor coordination and eye-control activities. All activities were done in a group, except for the eye control activities. The program was progressively adapted once a week. The SC was centred around the discovering of the self as well as a session for the parents with parenting skills. It was given once weekly 45 minutes for 8 weeks. During P-MI the children followed two motor programmes of 30 minutes and one psychological program of 45 minutes for 8 weeks.	MIV contributed to the biggest change in motor proficiency with significant improvements in the M-ABC-total and all sub-tests after intervention and retention period, the self-concept did not improve significantly and the anxiety stayed the same after intervention. The motor proficiency and the self-concept of the P-MIV improved significantly after intervention, the anxiety decreased non-significant. The self-concept of the SC improved significantly after intervention whereas the motor proficiency stayed more or less the same and the anxiety decreased non-significant after intervention. The self-concept of the control group stayed the same after eight weeks non-intervention with a significant improvement in their motor proficiency and non-significant increase in their anxiety.	2 (7/10)
Peters JM. 1999[198]	A preliminary pilot study. N=14	DCD, 11M/3F, n=9 of 7y, n=7 of 8y.	Category: other approaches Progressive group intervention was given by a class teacher using a detailed plan for each session. Children used balls, jumped, did balance exercises to reduce stress, affect sensory and motor development and encourage visualising and forward planning. They also performed strong exercises for abdominal, trunk and shoulder girdle musculature. The children practiced in various positions. Intervention was given for 10 sessions of 1 hour weekly.	Results show that 12 out of 14 participants improved in motor competence. There was a significant increase in FVC, participants were audibly less out of breath after the 10 weeks intervention. There was no change in the Perceived Competence Test.	3 (3/10)

Pless M. 2000[199]	A randomized controlled trial. N=17 Intervention group N=20 Control group	5 and 6 y children with DCD Intervention group 13M/ 4F, mean age 5y11mo. Control group 13M/7F mean age 6y	Category: task-oriented approach Group motor-skill intervention once weekly for 10 weeks which included functional skills, balance, ball and gross motor skills. The child was asked to practice the motor task at home between the meetings.	After intervention significantly more children with borderline motor difficulties in the experimental group than children with definite motor difficulties had improved and no longer had motor difficulties.	2 (7/10)
Pless M. 2001[129]	A randomized controlled trial. N=37 Study group N=60 Reference group	5-6y children with DCD. Study group 26M/11F girls, mean age 5y11mo. Reference group 31M/ 29F, mean age 5y8mo	Category: other approach Group motor skill intervention for 10 school-days, every day for 20-25 minutes. Children ran, jumped on one foot, practised long jump, balanced on a beam, turned somersaults, skipped with a rope and caught and bounced balls.	Motor skill intervention had no effect on the median total score of both self-perceived competence scales, but resulted in a significantly greater change in total score in the PMC scale on individual level in children in the intervention group.	2 (6/10)
Pless M. 2002[290]	A non-experimental descriptive study to re-examine children at 7-8 y old to determine their motor status and compare this with the age of 5-6 y. N=37	7 and 8y children 26M/ 11F Control group=none. Population: DCD on M-ABC ≤ 15th percentile	Category: other approach / natural outcome There was no intervention, just a 1 ½ year interval before retesting.	Children with definite motor difficulties at the age of 5-6 y continue to have these problems at 7-8 y. Parents' descriptions of the motor status of their child at 7-8 y are in agreement with the motor status as measured with a motor test.	3 (3/10)
Polatajko HJ. 1995[219]	A randomized clinical trial. N=76 Children were divided into three groups in blocks of 6 according to their age (7-8y, 9-10y and 11-12y): N=26 KT group, n=24 traditional therapy group, n= 24 control group.	DCD 54M/22F, mean age 9.06y	Category: process-oriented approach vs. other approach KT as described by Laszlo and Bairstow using kinaesthetic acuity, perception and memory apparatus in one-to-one sessions with an occupational therapist. Treatment was given 2-3 times a week 20 minutes for 5-12 sessions over 11 weeks. Traditional therapy: a combination of sensory integrative, fine motor, gross motor and perceptual-motor activities in one-to-one sessions with an occupational therapist. Treatment was given 2-3 times a week 45 minutes for 24 sessions over 9 weeks. Control group: no intervention for 11 weeks.	The group receiving kinaesthetic training as described by Laszlo and Bairstow improved significantly in kinaesthetic acuity. No significant differences were found in kinaesthetic perception and memory or the VMI either between groups or across time.	2 (7/10)
Richardson AJ. 2005 [227]	A randomized controlled trail. N=117, treatment in parallel groups for 3 months followed by 1-way cross over for 3 months.	DCD N=117, 78M/39F 5-12y Intervention (I) was 3 months fatty acids. Control group=placebo of olive oil. Control group received also active treatment after 3 months during 3 months.	Category: other approach 3 months fatty acids. Control group=placebo of olive oil. Control group also received active treatment after 3 months during 3 months.	No effect of treatment on motor skills were found after 3 months active treatment, but significant improvements in reading, spelling and behaviour for active treatment versus placebo were found. After 1-way crossover similar changes were seen in the placebo-crossover group, whereas children continuing active treatment maintained or improved their progress.	1 (10/10)

Schoemaker MM. 2003[195]	A controlled trial. N=15	DCD. N=10 Intervention group 7M/3F, age 7.1-9.2y N=5 control group 2M/3F, age 7.1-9.2y)	Category: task-oriented approach 18 times once a week for 30 minutes NTT training those skills a child found difficult during the assessment. Skills practiced were handwriting-quality, manual dexterity, ball skills and balance.	After 9 sessions no significant improvements for gross and fine motor skills on the M-ABC. After 18 sessions significant improvements for manual dexterity, ball skills and handwriting quality but not for balance and handwriting speed were found.	2 (5/10)
Sims K. 1996[179]	A randomized clinical trial. N=20	clumsy children 14M/6F, mean age 8y10m. Group A n=10 mean age 8y11m. Group B n=10 mean age 8y9m	Category: process-oriented approach Intervention was given individually. KT consisted of activities to train the kinaesthetic acuity and perception and memory components designed by Laszlo and Bairstow. Intervention was given to group A over ten schooldays, every day for 20-25 minutes. After ten intervention sessions group B began their kinaesthetic training	Laszlo's training provides immediately after intervention an improvement in balance and larger improvements on kinaesthetic acuity, while improvements on handwriting and shape-copying became clear after three months follow-up.	2 (6/10)
Smits-Engelsman BCM. 2001[203]	A controlled trial. N=24	N=12 Intervention group 8M/4F, mean age 8.4y with poor handwriting N=12 control group 6M/ 6F, mean age 8.6y with good handwriting	Category: task-oriented approach Child-specific therapy was based on individual assessment results. NTT Therapy was given 18 times over a period of 3 months build on three elements: 1.pre-writing exercises, 2. fine motor training, 3. gross motor function training	Intervention improved handwriting quality after 3 and 12 months Handwriting speed improved significant after 12 months. A significant difference in trajectory length was found. For movement time, velocity and number of velocity peaks no significant main effects were found. No differences were found for pen pressure.	2 (4/10)
Sudsawad P. 2002[220]	A randomized controlled trial. N=45	Children aged 6-7y with handwriting problems Children were divided into three groups: 1. kinaesthetic training (KT) group 2. handwriting training 3. no treatment	Category: task-oriented approach (handwriting) vs. process-oriented approach All children received 6 daily sessions of 30 minutes.	Children who received kinesthetic training did not improve significantly more on kinaesthetic acuity, perception and memory and handwriting legibility than children who received handwriting practice or no treatment.	1 (9/10)
Sugden DA. 2003[188]	A randomised controlled cross-over study. N=31	DCD 22M/9F, mean age 8.04y Children were divided in two groups.	Category: task-oriented approach one group working with teachers where the activities were incorporated within the normal school routine for 7 weeks C: one group working with the parents where the activities were incorporated within the normal routine at home for 7 weeks After 7 weeks the groups switched over for 7 weeks. Parents and teachers were given guidelines	Results show that without intervention no improvement took place. As a result of treatment the children made significant gains in their motor performance with p<. 0001.	2 (6/10)
Tsai CL. 2009[187]	A quasi-randomized controlled trial N=14 DCD-table tennis training group N=14 DCD-non-training group N=29 typically developing children	Children of 9-10y with DCD	Category: task-oriented approach Task specific group training given for 10 weeks, 3 times a week during 50 minutes consisting of a warming-up, playing table tennis game with partner and cooling-down. The DCD non-training group and the control group performed their regular classroom activities and did not participate in any training.	Intervention improved motor performance, reaction time and inhibitory control.	2 (6/10)

Watemberg N, Waiserberg N, Zuk L, Lermann-Sagil T. 2007[190]	A randomized controlled trial N=28	DCD+ADHD, age range (6-12y)	Category: task-oriented approach Cognitive task-oriented approach, 30 min p/d C:. no intervention	Intervention improves M-ABC scores	2 (7/10)
Ward A, Roger S. 2004[291]	Single case studies N=2	6y, total scores <15th percentile on M-ABC, motor coordination difficulties conflicting with activities of daily living, average IQ	Category: task-oriented approach CO-OP, 5 weeks. 2x p/w, 1h individual treatment	Two children 5-7y benefited from CO-OP, extra care must be taken regarding task attention and goal motivation	3 (4/10)
Wilson PH. 2002[191]	A randomized controlled trial. N= 18 Imagery Training Group, N=18 Perceptual-Motor Training Group, N=18 control group	Children with motor coordination difficulties. Age ranged from 7y to 12y.	Category: task-oriented approach vs. some aspects of process-oriented approach Imagery Training is individual training consisting of visual imagery exercises involving predictive timing, relaxation protocol and mental preparation, visual modelling of fundamental motor skills, mental rehearsal of skills from an external perspective and overt practice. Perceptual-Motor Training corresponded with conventional physical therapy. It consisted of individual training with a combination of gross-motor, fine-motor and perceptual-motor activities. Intervention was given for 60 minutes, once a week for 5 weeks.	The imagery and perceptual-motor training groups showed significant improvements in their coordination level from pre- to post-test, with a moderate magnitude of change.	1 (8/10)

13.7Additional statement for countries ascribing to the DSM classification

*Additional statement for countries ascribing to the DSM IV-TR classification

2a	**Recommendation 2a** **The diagnosis of DCD should be given if the following criteria are met:** A. Motor performance is substantially below expected levels, given the child's chronological age. The poor motor performance may manifest as: – poor balance, clumsiness, dropping or bumping into things, or – marked delays in achieving developmental motor milestones (e.g. walking, crawling, sitting) and – persistent difficulties in the acquisition of basic motor skills (e.g. catching, throwing, kicking, running, jumping, hopping, cutting, colouring, printing, handwriting) B. The disturbance in Criterion A significantly interferes with activities of daily living or academic achievement (e.g. self-care and self-maintenance; academic/school productivity, pre-vocational and vocational activities, and leisure and play) *C. If the disturbance is not due to a general medical or specific neurological disorder (e.g., cerebral palsy, hemiplegia, or muscular dystrophy) (acc. to DSM IV)* *D. If mental retardation is present the motor difficulties are **in excess of** those usually associated with it (acc. to DSM IV).* *The disturbance cannot be explained by severe behavioural problems, e. g. severe attentional problems or autistic spectrum disorders or severe psychosocial problems (e. g. deprivation)* *Comment: Clarification for Criteria C and D:* – *DCD should **not** be diagnosed if a motor test cannot be administered and if after a comprehensive assessment (including a clinical history, examination, and consideration of teacher and parent report) the motor dysfunction can be explained by another medical condition, psychosocial disorder or severe mental retardation.* – *Though not diagnostic, some children with DCD show 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.* – *Applying 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 recognised that categorical decision (above or below IQ level) may be extremely difficult. Moreover, enforcing these diagnostic decisions may not be useful on the basis of what is currently known about neurocognitive development.*	**GCP++**

6a	**Recommendation 6a** **A dual diagnosis of DCD and other developmental or behavioural disorders (e.g. autism spectrum disorders, learning disorders, ADHD) should be given if appropriate and priorities for intervention should be determined in keeping with the dysfunctions present.** **Key comment (only for countries using DSM classification)** In contrast to the DSM IV TR Criterion C the guidelines group does not exclude a combined diagnosis of autism spectrum disorders and DCD as there are no data supporting a specific subtype of motor disturbance in children with autism spectrum disorder or a specific coexistence being different from other children with DCD (see also recommendation 2a).	**LOE 0 (for exlusion of autism)** **A**

13.8Abbreviations

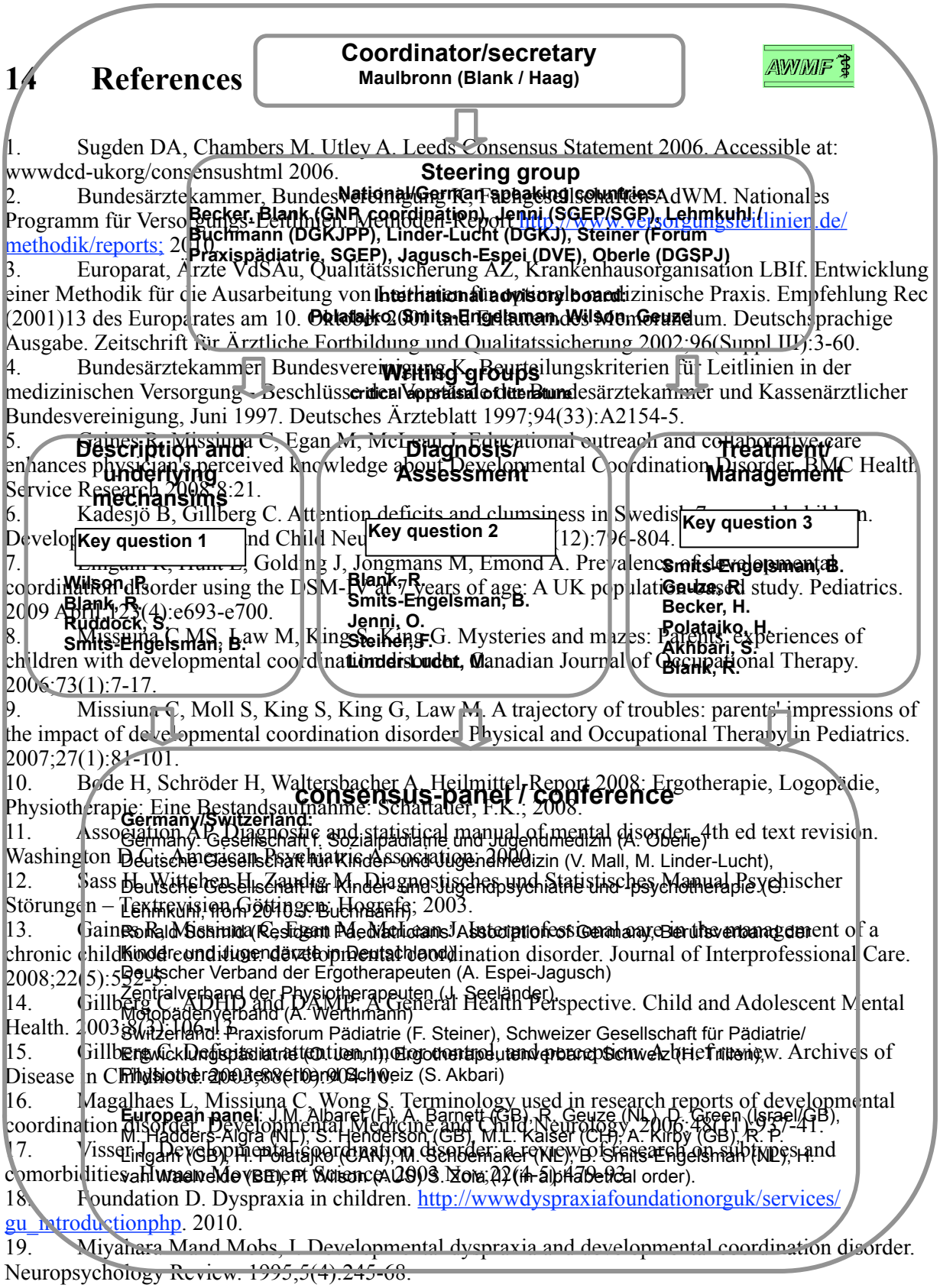
Abbreviation	Full name
ADHD	Attention Deficit Hyperactivity Disorder
ADL	Activities of Daily Living
ASD	Autistic spectrum disorder
AWMF	Association of the Scientific Medical Societies in Germany
BHK	Beknopte Beoordelingsmethode voor Kinder Handschriften
BOTMP (-2) / SF	Bruinincks-Oseretzky Test for Motor Proficiency (-2nd revision) / short form
BSID	Bayley Scales of Infant Development
CD	Conduct disorder
CO-OP	Cognitive-Orientation to Occupational Performance
COPM	Canadian Occupational Performance Measure
CPG	Clinical Practice Guideline
CR	Comprehensive review
CSAPPA	Childrens Self-Perceptions of Adequacy in and Predilection for Physical Activity
CTA	Contemporary treatment approach
DAMP	Deficits in Attention, Motor control and Perception
DASH	Detailed Assessment of Speed of Handwriting
DCD	Developmental Coordination Disorder
DCD-Q (-R)	DCD-Questionnaire (-revised version)
DELBI	German Instrument for guideline evaluation
DSM	Diagnostic Statistic Manual
EACD	European Academy of Childhood Disability
ELBW	Early low birght weigth
ETCH	Evaluations Tool of Children`s Handwriting
F	female
FVC	Functional Vital Capacity
GCP++ or +	Good Clinical Practice (recommendation based on strong consensus; ++ >95% of the participants, + 75 to 95% or the participants of the nominative group process)
GRADE	Grading of Recommendations Assessment, Development and Evaluation
h	Hour
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
KT	Kinaesthetic Training

KTK	Körperkoordinationstest for Children
LBD	Le Bon Départ
LOE	Level of evidence
m	Month
M	Male
MA	Meta-analysis
M-ABC (-2)	Movement Assessment Battery for Children (-2nd revision)
M-ABC-C	Movement Assessment Battery for Children - Checklist
MAND	McCarron Assessment of Neuromuscular Dysfunction
MI	Motor imagery training
min	Minutes
MIV	Motor based Intervention
MPC	Motor Performance Checklist
MPH	Methylphenidate
MTPT	Motor Teaching Principle Taxonomy
NDT	Neurdevelopmental Treatment
NPV	Negative Predictive Value
NTT	Neuromotor task training
OP	Original papers
OT	Occupational therapy
p/d	per day
p/w	per week
PDD	Pervasive Developmental Disorder
PDMS	Peabody Developmental Motor Scales
PMB	Perceptuo-Motor Battery
P-MI	Psycho-motor intervention
PMT	Perceptual Motor Training / Therapy
PPV	Positive Predictive Value
PT	Physiotherapy
RCT	Randomized Controlled Trial
RD	Reading disability
SCSIT	Southern California Sensory Integraton Tests
SDDMF	Specific Developmental Disorder of Motor Function
SI	Sensory Integration
SI / SIT	Sensory Integration / Sensory Integration Therapy
SOS	Systematische Opsporing van Schrijfproblemen
SR	Systematic review
TAC	Trouble de l'acquisition de la coordination
TAK	Tactile perceptual tests

TEAF	Teacher estimation of activity form
TGMD-2	Test of Gross Motor Development second edition
VAS	Visual Analogue Scales
VMI	Visuomotor Test
w	weeks
y	year/years
ZNA	Zuerich Neuromotor Assessment Battery

13.9Organisational framework

Figure 3: Names and jobs of the guideline group and consensus panel



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