

MSPT

**Best-evidence based physiotherapy and occupational therapy intervention
for children with Developmental Coordination Disorder (DCD):
a systematic review**

Thesis

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Abstract

Objective: To systematically review the best-evidence regarding physiotherapy and occupational therapy interventions for children with DCD.

Method: Studies published between 1995-2010, describing a systematic review or (randomized-) clinical trial about physiotherapy or occupational therapy intervention for children with DCD or motor impairment (not due to a medical condition) with a test score of at least 1 standard deviation below the mean, were included. Studies were processed in an evidence table.

Results: 31 differently titled interventions were investigated. Sensory Integration Therapy is most frequently researched (9). Followed by Perceptual Motor Training (8). Cognitive Orientation to daily Occupational Performance and Neuromotor Task Training were both researched in 3 separate studies.

Conclusion: The positive effect of physiotherapy and occupational therapy interventions in children with DCD is strongly supported in all available literature. Individualized, functional and specific skill interventions appear to be the most effective.

Keywords: DCD, motor impairment, physiotherapy, occupational therapy, intervention.

Introduction

In earlier studies it is well documented that Developmental Coordination Disorder (DCD) has a heterogeneous and complex presentation of marked impairment in the motor capacity of children affected by it^{1,2}. The Diagnostic and Statistical Manual for Mental Disorders (DSM-IV) cites the prevalence of DCD at 6% for children between 5-11 years³. The prevalence of DCD in boys is reported to be higher than that of girls; the boy-girl ratio is at least 2:1⁴. According to the DSM-IV classification of DCD, the children experience major problems in activities of daily living and in participating at the level of their peers in school and sports. The problems that children with DCD experience are severe and persistent, they are not due to a general medical condition, do not meet the criteria for Pervasive Developmental Disorder and if mental retardation is present, the motor difficulties are in excess of those naturally associated with it³.

Earlier research has concluded that DCD is not a condition that just belongs to childhood years; a child with DCD does not outgrow his or her motor impairments and related problems

^{4,5,6,7}. The prevalence of continuation of difficulties, classified as DCD in adolescents and adults, is estimated between 30-87%^{8,9,10}. This figure varies because of the use of children's measurements in diagnosing adolescents and adults, because of selection criteria, severity of symptoms and/ or if the individual has overlapping diagnosis with other developmental disorders such as Attention Deficit Hyperactivity Disorder (ADHD), Dyslexia and Asperger's Syndrome. Studies have shown a high rate (60%) of co-occurrence between DCD and ADHD¹¹. This combination seems to predict a worse long-term prognosis¹². In a large percentage, the adolescence and adulthood of people with DCD is characterized by continuing motor difficulties in addition to social and educational problems, medical and psychiatric consequences^{5,11,13,14,15,16}.

It is therefore important that a child with DCD receives the appropriate healthcare guidance in a multidisciplinary team^{7,17,18}. Within this team, a physiotherapist or occupational therapist is the most capable professional on the area of motor learning¹⁹.

In the past 15 years, several articles have been written about the available physiotherapeutic and occupational therapy interventions for children with DCD ^{6,17,19,20,21}. These interventions can roughly be divided into 2 approaches.

On the one hand, the so called underlying deficit approaches like Perceptual Motor Training (PMT), Sensory Integration Therapy (SIT), process-oriented treatment and Kinesthetic Therapy (KT). The objective of these approaches is to remedy the underlying deficit in body functions and –structures ^{6,14,15,20,22,23,24,25}.

Contrary to these approaches are the specific skill interventions. They typically engage the teaching and training of activities in daily living towards participation. These approaches are not trying to remedy any particular structural or process deficit but, instead, work on teaching the activities that the child needs to be able to participate in his or her daily life. Cognitive Orientation to daily Occupational Performance (CO-OP) and Neuromotor Task Training (NTT) are specific skill interventions ^{6,14,15,20,22,23,24,25}.

This review is written in the context of developing the international Clinical Practice Guideline for DCD (EU-guideline). This guideline aims to improve detection of DCD. It also tries to increase the use of effective treatment and quality of life. Moreover it aims at improvement of participation in activities at home, school and leisure and to improve access to health care services ²⁶.

The objective of this study is to systematically review the best-evidence based interventions that could be used by the physiotherapist or occupational therapist in the treatment of children with DCD.

The aims are to:

1. point out which of the physiotherapeutic and occupational therapy interventions for children with DCD has been shown to be the most effective one,
2. describe the implications regarding the guidance and treatment of the physiotherapist or occupational therapist and give suggestions for future research.

Methods

In- and exclusion criteria

In advance of the actual literature search, selection criteria were set. Only systematic reviews, meta-analysis, randomized clinical trials (RCT) and clinical trials (CT) were included. The studies should have been written in English, German or Dutch and published between 1995-2010.

The populations used in the included studies were children of any age, identified with or with possible DCD. DCD is defined either according to the criteria of the DSM-IV or as motor impairment not otherwise specified by a medical diagnosis, but examined with standardized motor measurement tests confirming motor impairment.

Case studies, follow-up studies, descriptive studies, studies with a methodological quality level 'D', according to the classification of the Dutch Institute for Health Care Improvement (CBO) (see Table 1), studies investigating a sample of children with a neurological diagnosis, and/ or syndrome, and/or muscular disorder, were excluded from this review.

From the selected studies, only the ones researching the outcome of physiotherapy or occupational therapy interventions were used for this paper. The included studies had to have outcome measures on motor capacity, measured with standardized and internationally accepted assessments (e.g. Movement Assessment Battery for Children, Test of Gross Motor Development – second edition, Bruininks-Oseretsky Test of Motor Proficiency or Concise Assessment Scale for Children's Handwriting).

Literature search

The actual search took place in July 2009, and was repeated in January 2010 to find the most up to date information. Databases that were consulted were: Medline, Cochrane-Library, PubMed, CINAHL, PsychInfo, PsychLit, OTDBase, OTseeker, PEDRO, ERIC, Embase and HealthSTAR. The search terms were constructed in a meeting of the international working group for the EU-guideline in 2008 and later accepted and extended by the authors.

The search terms include the current nomenclature related to DCD and the formerly terms describing the problems that relate to

DCD: *motor skills disorder, developmental coordination disorder (DCD), clumsiness, clumsy, clumsy child syndrome, clumsy child, in-coordination, dys-coordination, minimal brain dysfunction, minor neurological dysfunction/ disorder, motor delay, perceptual-motor impairment, 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), apraxias, developmental dyspraxia, perceptual motor dysfunction, minimal cerebral dysfunction.*

For every search term that uses '*coordination*', there has also been searched with an alternative spelling '*co-ordination*', and for the terms using a 'dash' (-), e.g. '*motor-impairment*', there has also been searched without the 'dash', e.g. '*motor impairment*'.

All above terms were combined with *physical therapy, physiotherapy, occupational therapy, intervention, treatment, long term outcomes,*

parents, teachers, effectiveness, efficiency, coping, co-morbidities, ADHD, dyslexia, dyscalculia, PDD-NOS, ADD, autism, IQ, SI, NDT, NTT, CO-OP, PMT, Motor Imagery Training, Sensory Integrative Training, Task-specific Training, Cognitive Orientation to daily Performance, Cognitive Training, Timing control, Kinesthetic Training.

Limits were set on: Humans, Clinical Trial, Meta-Analysis, Randomized Controlled Trial, Review, English, German, Dutch, All Child: 0-18 years, Publication Date from 1995/01/01 to 2010/01/15. To prevent finding a large quantity of literature about cerebral palsy, stroke, traumatic brain injury, leucodystrophia or muscular disorders, the search was limited for these terms by using the word 'NOT' in the query.

Methods of the review

The abstracts resulting from the search were individually rated by the authors to include or exclude. When consensus existed about the included abstracts, the full text articles were evaluated.

To increase the reliability of the interpretation

of the conclusions and decrease readers-bias, literature was rated separately by 2 evaluators. After that, these individually operating evaluators had to come to consensus about the in- or exclusion of a paper. For included studies, they had to agree on the level of evidence, or in case of a RCT, also about the PEDro-score (Physiotherapy Evidence Database). When the 2 evaluators could not come to consensus, the 3rd researcher of the project group was consulted.

To systematically report the methodological quality of individual studies (see Table 1), the CBO-classification was used. Levels of evidence reflect the degree to which bias has been considered in the study design, a level A indicating less bias than a level D²⁷. The level of evidence of individual studies relates to the significance of the overall conclusion about the effectiveness of an intervention, a lower number on the hierarchy indicating stronger evidence for the intervention (see Table 2).

Table 1: Level of evidence, methodological quality of individual studies²⁷

Level	Definition
A1	Systematic review of at least 2 independently researched studies of A2-level
A2	Randomized, double-blind, controlled clinical trial of good methodological quality and large enough population
B	Comparative study, without all the items mentioned for a A2-level, also cohort studies
C	Non-comparative study
D	Expert opinion

Table 2: Level of evidence, significance of the conclusion²⁷

Level	Conclusion based on...	Formulated in text as...
I	Study of level A1 or at least 2 independently researched studies of A2-level	"It is proved that..."
II	Study of level A2 or at least 2 independently researched studies of B-level	"It is possible that..."
III	Study of level B or C	"It may be that..."
IV	Expert opinion	"It is the expert's opinion that..."

Each included study was processed in an evidence table to record author, title, level of evidence on methodological quality of individual studies, population description, number of participants, age and relevant baseline testing results, type of intervention, description of the intervention, frequency, intensity and duration, outcome measures, description of results of the populations, short description of the conclusion and limitations, PEDro-score and main conclusions. A PEDro-score of 7 or higher is qualified as a good, reliable study, a score of 5 or 6 is still acceptable²⁸.

From the studies that were included for the EU-Guideline, a selection was made by the authors, according to the in- and exclusion criteria mentioned above (see Figure 1). The height of the PEDro-score was not a factor of

influence for the in- or exclusion of studies.

Data synthesis

The included studies were grouped in a table which can be found under the heading 'results' (Table 3). These studies were ranked by level of evidence of their methodological quality (level A1-C, see Table 1) and type of intervention.

The results were summarized as either a '+' for significant improvement in the experimental group(s) or '0' for no change. Positive improvements were defined by a p-value of <.05.

To allow consideration of the body of evidence, the significance of the conclusion (level I-IV, see Table 2) about the interventions investigated, was applied.



Figure 1: flowchart of the literature selection process

Abbreviations: PT = Physiotherapy, OT = Occupational Therapy

Results

The absolute product of the search, with hits matching the queries, were 3703 studies, of which the abstracts were read to include or exclude. The authors divided 127 full text studies that seemed to be of interest for evaluation over 2 individual researchers. They decided that 47 papers were found to be useful

for the EU-Guideline, an additional 5 related studies were also included by cross referencing. From these 52 papers that were used in the EU-Guideline, 33 of them were excluded for this study. To answer to the questions posed in this systematic review, 19 studies were included (see Figure 2).



Figure 2: flowchart literature search July 2009 – January 2010

Abbreviations: n = number; PT = Physiotherapy; OT = Occupational Therapy

Level and quality of evidence

Nineteen studies were meeting the inclusion criteria. The dates of publication ranged from 1995 to 2009. Of those 19 articles, 1 was a systematic review, all others were primary studies. The primary studies were scored for their methodological quality with the PEDro-scale. The overall quality was variable with a

mean of 5.78, range 3-8 (maximum score out of 10).

After careful analysis of all included studies, a decision was made to accept and copy the results published in Hillier's systematic review. The primary studies that were included both in Hillier's systematic review and this study, are not shown in Table 3 under the

included studies, with the reason to give the reader a clear view on the results, not troubled by double analyzed studies. A complete

overview of the results published in all 19 included studies, is available from the first author.

Table 3: Included studies, ranked by level of evidence of the study and in case of an RCT also with PEDro-scores (P/ 10), than by intervention. Abbreviations below the table.

Level of evidence (P/10)	Intervention	Author, date	Sample size	Outcome assessment	Authors' conclusions
A1	CA, CO-OP, CTA, Effort training, Ex, Gp, Guided teacher/parent, Home ex, Indiv. PT/ OT/ tutoring, KT, KT/S/T, LBD, Mastery, MI, NTT, Parent assisted, PMT, PO, SIT, Spatial training, Specific skill intervention, Task specific reps, Traditional, Usual sport, WB, Writing	Hillier, 2007 ²¹	n = 1105, DCD in 31 studies (Level I-III), publication date 1970-2004	Various in studies	Motor intervention per se is better than no intervention. There may be generic qualities of factors in the studied interventions that are more important for effectiveness than specific content. Strong evidence for effectiveness in PMT, SIT, PT and Mastery concepts. Moderate evidence for KT.
B (P/ 8)	CO-OP vs. NI (cross over)	Green et al., 2008 ²	n = 43, DCD with co-morbidities as PDD, ADHD, Medical or SLI	MABC	CO-OP +, NI 0
B (P/ 6)	CO-OP vs. CTA	Sangaster et al., 2005 ²⁹	n = 18, DCD with ADD/ADHD/LD CO-OP: n = 9 (2 with ADD/ADHD, 1 LD) CTA: n = 9 (1 with ADD/ADHD)	Behavioral observations	CO-OP +, CTA + but less strategy generation
B (P/ 7)	KT, PMT, SIT, NDT, with task specific approach + home muscle strengthening, stretching and balance exercises vs. no NI	Waternberg et al., 2007 ¹⁹	n=28, DCD with ADHD and co-morbidities as SLD, ODD, CD, MD, anxiety, DLD or tic disorder Intervention: n = 14 Controls: n = 14	MABC	KT, PMT, SIT, NDT with task specific approach and home exercises +, NI 0
B (P/ 7)	KT vs. OT vs. NI	Polatjko et al., 1995 ³⁰	n = 74, DCD KT: n = 26, OT: n = 24, NI: n = 24	KST, VMI, TOMI, SC-SIT	KT + more than OT + on KST. KT, OT, NI 0 on other outcome measures.
B (P/ 7)	Motor vs. psychomotor vs. psychological intervention vs. NI	Peens et al., 2008 ¹⁸	n = 58, DCD	MABC, TSCS-CF, CAS	Motor +, psychomotor + on MABC. Psychomotor +, psychological + on TSCS-CF. NI 0 for all tests. All 0 on CAS.
B (P/ 6)	Gp table tennis vs. NI	Tsai, 2009 ¹⁴	n = 28, DCD, divided in intervention group and NI group n = 29, TD	MABC, visuospatial attention test, reaction time	Gp + on MABC and stronger inhibitory control effect. NI 0
B (P/ 6)	Gp motor training vs. NI	Pless et al., 2001 ³¹	n= 97, DCD Gp: n = 37, NI: n = 60	TOMI, KST, PMC	Gp + on PMC, NI 0
C (P/ 3)	Gp	Peters et al., 1999 ²⁵	n = 14, DCD	MABC, FVC, PCS	Gp + on MABC, FVC. Gp 0 on PCS.
B (P/ 6)	NTT vs. NI	Niemeijer et al., 2007 ³²	n = 39, DCD NTT: n = 26, NI: n = 13	MABC, TGMD-2	NTT + on MABC, TGMD-2. NI 0
C (P/ 4)	NTT	Niemeijer et al., 2006 ³³	n = 19, DCD	MABC, TGMD-2, MTPT	NTT + MABC, TGMD-2. MTPT giving clues and adjusting body position associated with treatment effects
B (P/ 5)	Writing	Jongmans et al., 2003 ³⁴	n = 74, dysgraphic writers	CASCH	Writhing + on CASCH
B (P/ 4)	PT based on individual assessment results	Smits-Engelsman et al., 2001 ³⁵	n = 24 n = 12 poor writers n = 12 good writers	CASCH, MABC flower-trail	PT + on CASCH, MABC flower-trail

Explanatory notes and abbreviations (by column and alphabet):

Level:

Levels I-III: refer table 2 for definitions

(P/ 10): quality score out of 10 total for PEDro-score

Intervention with frequency of investigation in parenthesis:

CA: Cognitive Affective – tasks (draw, mime, visual) with emphasis on experiencing success and self monitoring (1)

CO-OP: Cognitive Orientation to daily Occupational Performance (3)

CTA: Contemporary Treatment Approach (2)

Effort training: based on training the specific movement qualities proposed by Laban (1)

Ex: exercises (1)

Gp: group program (5)

Guided teacher/ parent: intervention prescribed by therapists for teachers/ parents to conduct (1)

Home Ex: home exercises prescribed by PT (2)

Indiv. PT/ OT: individual physiotherapy and/ or occupational therapy (3)

Indiv. Tutoring: provided one on one teaching (1)

KT: Kinesthetic Training – process oriented approach proposed by Laszlo (5)

KT/S/T: Kinesthetic Training with spatial and temporal programming (2)

LBD: Le Bon Départ – psychomotor therapy, includes emphasis on music and rhythm (1)

Mastery: training paradigm that complies with requirements for high autonomy level versus low autonomy/ mastery (1)

MI: Motor Imagery – training in visual, predictive timing, relaxation, mental preparation, modeling, mental rehearsal (1)

Motor intervention: integration of task-specific, kinesthetic and sensory integration treatment in a group program (1)

NDT: Neuro Development Treatment – not specified (1)

NI: no intervention

NTT: Neuromotor Task Training – task oriented approach, based on recent motor learning and motor control research (3)

OT: Occupational Therapy

Parent assisted: home exercises prescribed by therapist and conducted by parents (1)

PMT: Perceptual-Motor Therapy based on Bobath (8)

PO: Process Oriented – based on kinesthetic training proposed by Laszlo (1)

Psychological intervention: centered around discovering the self (1)

Psychomotor intervention: combination of motor intervention and psychological intervention (see motor/ psychological intervention) (1)

SIT or SI: Sensory Integration (Therapy) – based on Ayres (9)

Specific skill interventions: delivered in groups or at home (1)

Spatial training: based on Laszlo (1)

Task specific reps: repetitive training or practice that is specific to a task (2)

Usual sport: participation in usual school based sporting activities (1)

WB: weight bearing - kinesthetic training (1)

Writing: high motor content (1)

Sample size

ADD/ ADHD: Attention Deficit Disorder/ Attention Deficit Hyperactivity Disorder

CD: Conduct Disorder

DCD: Developmental Coordination Disorder

DLD: Developmental Language Delay

LD: Learning Disorder

MD: Mood Disorder

N: number

ODD: Oppositional Defiant Disorder

PDD: Pervasive Developmental Disorder

SLD: Specific Learning Disability

SLI: Speech Language Impairment

TD: Typically Developing

Outcome assessment, with frequency use in parenthesis

CAS: Child Anxiety Scale (1)

CASCH: Concise Assessment Scale of Children's Handwriting (3) (BHK)

FVC: Forced Vital Capacity – maximum volume of air that can be expelled with effort from the lungs, measured with microspirometry (1)

KST: Kinesthetic Sensitivity Test (3)

MABC: Movement Assessment Battery for Children (5)

MTPT: Motor Teaching Principles Taxonomy (1)

PCS: Perceived Competence Scale (1)

PMC: Perceived Motor Competence scale (1)

SC-SIT: Southern Californian Sensory Integration Tests (1)

TGMD-2: Test of Gross Motor Development (2)

TOMI: Test Of Motor Impairment (precursor of MABC) (2)

TSCS-CF: Tennessee Self-Concept Scale – child form (1)

VMI: developmental test of Visual Motor Integration (1)

Authors' conclusions (see intervention and outcome assessment for most abbreviations)

+: significant improvement in the experimental group(s)

0: no change

Sample size

A total of 1535 children with DCD or motor impairment classified with a test score of at least 1 standard deviation below the mean, not otherwise specified by a medical diagnosis, participated in the included studies. The largest sample, (n = 1105), was generated by the combined studies of the systematic review performed by Hillier (2007).

Outcome measures

Taken all included studies together, 50 different outcome measures were reported. The Movement Assessment Battery for Children was the most frequently used outcome measure (5). This was followed by the Concise Assessment Scale for Children's Handwriting, used 3 times. Both the Test Of Motor Impairment and the Test of Gross Motor Development – Second edition were used in 2 studies.

These outcome measures are all standardized, general assessments for gross or fine motor function. Outcome measures that were reported less frequently were often specific for the intervention method investigated. The overall frequency of usage of outcome measures in the primary studies is noted in parenthesis after

each outcome assessment definition following Table 3.

Interventions

In total, 31 differently titled approaches to physiotherapy or occupational therapy intervention were investigated in the included studies. All approaches mentioned in this review, are described by their nomenclature that was used in the original articles. Thereby assuming that the authors, who were researching a particular named approach, were actually using the same approach.

The most common investigated approach was Sensory Integration Therapy (SIT). It was investigated for its effect 9 times. Followed by Perceptual Motor Training (PMT) which was investigated 8 times. Kinesthetic Therapy (KT) and group therapy interventions, respectively, were investigated for their effect 6 and 5 times. Interventions as Cognitive Orientation to daily Occupational Performance (CO-OP) and Neuromotor Task Training (NTT) were both reported in 3 studies.

The first important finding is that *it is proved that* any physiotherapy or occupational therapy intervention is better than no intervention for

children with DCD. Eleven studies used a control group that did not receive any intervention. Of those studies, 9 concluded that children with DCD who did not receive any physiotherapy or occupational therapy intervention, showed no change at the post tests^{2,14,18,19,20,24,31,32,36}.

Pless et al. (2000) concluded in her meta-analysis, based on 13 studies comparing 3 different interventions (general, sensory integration and specific skill), that specific skill interventions are most effective in children with DCD of 5 years or older³⁷. It can therefore be stated that *it is proved that* specific skill interventions are effective in treating children with DCD.

PMT is reported by Hillier (2007) as an effective intervention method for children with DCD²¹. Her conclusions are based upon 2 well conducted Randomized Clinical Trials (RCT), 4 moderate RCTs and 1 moderate Controlled Trial (CT). Of those studies, 6 of them showed the positive effect of PMT on children with DCD. Watemberg et al. (2007) also proved the effectiveness of PMT, given in combination with other approaches¹⁹. It can be concluded

that *it is possible that* PMT is an effective intervention method for children with DCD.

Although SIT is the most commonly investigated approach, the evidence is conflicting: it is qualified by Hillier (2007) as being an effective treatment method in children with DCD²¹. Her conclusions were based on 1 meta analysis and 7 well designed RCTs. The meta analysis performed by Pless and Carlsson (2000) provided evidence that specific skill interventions in children with DCD from 5 years of age or older has greater support for effectiveness than SIT does³⁷. In 3 RCTs with PEDro-scores of 7, the effectiveness of SIT was measured with the Bruininks-Oseretsky Test of Motor Proficiency or academic tests. Those RCTs cannot prove the effectiveness of SIT. On the other hand, 4 RCTs with PEDro-scores between 6 and 7 claim the effectiveness of SIT on the SC-SIT and motor tests. Which motor tests have been used is not specified. Watemberg et al. (2007) concluded in his RCT that SIT is an effective treatment in children with DCD, given in combination with other intervention approaches¹⁹. It must therefore be concluded that *the evidence is inconclusive* for the effectiveness

of SIT as an intervention for children with DCD.

KT was also evaluated by Hillier (2007). She concluded that there is moderate evidence that the approach is effective, based on 1 moderate RCT, 1 CT of good quality and 1 moderate CT²¹. Importantly, the other studies investigating KT, not described by Hillier, were good quality RCTs with PEDro-scores of 7, but had inconclusive evidence for its effectiveness^{19,30}. The RCT performed by Watemberg et al. (2007) showed that KT is effective when given in combination with other intervention methods¹⁹. Polatajko et al. (1995) researched KT on its own and found only a treatment effect in favor of KT on the Kinesthetic Sensitivity Test, not on assessments for motor capacity³⁰. Regarding the highest level of evidence it is concluded that there is *inconclusive evidence* for the effectiveness of KT.

Group therapy for children with DCD is found to be effective in a qualitatively moderate RCT of Tsai (2009), by Pless (2001) in a moderate CT, and by Peters et al. (1999) in a low quality CT. Tsai (2009) showed that group therapy can

result in improved motor capacity, reaction time and inhibitory control in children with DCD, when group therapy consisted of table tennis training¹⁴. Peters (1999) concluded that after 10 weeks of progressive group exercises, children significantly improved in their test scores on the Movement Assessment Battery for Children and on Forced Vital Capacity (FVC), measured by microspirometry²⁵.

According to the study results of Pless et al. (2001), non-specific group motor skill intervention makes children between 5 and 6 years of age aware of their motor competence³¹. Hillier (2007) stated that there is only indicative evidence for the effectiveness of group therapy²¹.

Contrary, Pless (2000) conducted a RCT with a PEDro-score of 7 where children with DCD followed either group motor skill intervention or no intervention. Her conclusion was that children with borderline DCD (test score on motor test between 5-15th percentile) have profit from group therapy and children with definite DCD do not³⁸. Group therapy *may be* effective in children with borderline DCD.

Three CTs of high quality investigating CO-OP all measured positive treatment effects

^{2,5,29}. CO-OP has been described by Hillier (2007) as having limited evidence for effectiveness²¹. Also the effectiveness of NTT has been researched in 3 CTs, 1 with a PEDro-score of 6 and 2 with a PEDro-score of 3. These studies indicated that NTT is effective^{20,32,33}. Based upon these results, CO-OP and NTT *may be* effective interventions in children with DCD.

Individual physiotherapy was studied in 1 RCT of moderate quality and 2 moderate CTs, indicating that *it may have* positive effects^{21,39}. Motor Imagery (MI) in combination with a program of training fundamental motor skills has only been studied once in a high quality RCT²⁴. Wilson et al. (2002) showed positive effects for MI in combination with a training program, but with an equal improvement as to exercise alone²⁴. *It is possible that* MI in combination with a program of training fundamental motor skills is effective in children with DCD.

Discussion

First of all, the main conclusion of this systematic review is, that there is enough strong evidence available to confirm that any physiotherapy or occupational therapy is better than no intervention at all in children with DCD^{15,21,32}.

Next to this, there is evidence that children with DCD benefit the most from specific skill interventions³⁷. Specific skill interventions work on teaching essential activities of daily living and thereby stimulate participation of the child in school, leisure and sports^{6,14,15,20,22,23,24,25,37}. It appears that interventions that aim at improving body functions and – structures, like Sensory Integration Therapy (SIT) and Kinesthetic Therapy (KT), are less effective in children with DCD³⁷.

The original aim was to include only children with a test score below the 5th percentile. Unfortunately, a small amount of studies that researched this group of children were available. Therefore, also children with a motor capacity of 1 standard deviation below

the mean were included.

This systematic review investigated the literature from 1995 to January 2010; this period indicates a sort of transfer phase in the selection of the kind of children with DCD included. Since 1994 the terminology “DCD” has been introduced by the DSM-IV in the international community²². It meant the beginning of an attempt to create a uniform approach towards children with motor impairment, not otherwise specified by a medical diagnosis. At the Leeds consensus in 2006, internationally accepted DSM-IV-criteria were set for the diagnosis of DCD in children^{3,22}. The studies included for this systematic review have therefore been using a heterogenic population of children with DCD. As can be distilled out of Table 3, not only children with ‘pure’ DCD participated were included. In 4 of the 19 studies, children with DCD and co-morbidities participated. This could have blurred the results of the studies involved.

The effectiveness of Motor Imagery (MI) in combination with fundamental motor skill training must be taken carefully. Wilson et al.

(2002) used in his RCT a population of children with a test score below the 50th percentile²⁴. Of the total research population, only 61% of the children had a test score of at least 1 standard deviation below the mean. Conclusions about MI should therefore be interpreted with extra care. Because the research by Wilson et al. (2002) was the only 1 investigating the effect of MI, it was included in this study, recognizing that it did not meet all the inclusion criteria.

Interventions can best be evaluated by high quality studies that use standardized assessment methods testing generic motor competency^{25,35,40}. The fact that specific skill interventions, such as CO-OP and NTT, are pointed out as most effective, might partly be biased by the test use, because motor assessments include comparable functional skills.

The longer an intervention method exists, the more chance such an intervention method has been investigated for its treatment effects⁵.

This is certainly true for SIT and KT^{5,20}. Both interventions have showed varying effects^{5,21}. Positive treatment effects were found when

SIT or KT were used in a combination of intervention methods with Perceptual Motor Training (PMT), Neuro Development Treatment (NDT) and home exercises within a task specific approach¹⁹. In the daily practice of the physiotherapist and occupational therapist, it is common to combine several intervention methods in 1 treatment episode. In that way, a research with a combination of intervention methods could reflect the daily practice of professionals. However, for scientific reasons, this is not a good option because it does not show what part of the intervention caused the treatment effects.

The high amount of different interventions for DCD indicates a lack of knowledge about the etiology and therefore a lacking theoretic frame on which interventions are grounded^{1,6,7,14,15,17,19,20,23,24,35,40}. The working group of the EU-guideline is making an effort to get a better understanding about the etiology of DCD.

The Leeds consensus of 2006 has already set some guidelines to which an intervention approach should meet: activities that are functional, are based on those that are relevant

to daily living and meaningful to the child, enhance generalization and application in the context of everyday life, be evidence-based and grounded in theories that are applicable to understand children with DCD^{13,22}.

This systematic review not only shows that physiotherapy or occupational therapy in children with DCD is better than no intervention at all, but also that specific skill interventions sort the best treatment effects^{6,17,20,23,32,33}. Specific skill interventions typically engage the teaching of activities of daily living^{15,17,32,33,34}. These approaches are not trying to remedy any particular body function or – structure deficit, but instead work on teaching the activities that the child needs to be able to perform and participate in its daily living^{15,17,22,23,24}.

Conclusion

Physiotherapy or occupational therapy intervention in children with DCD is strongly supported in all available literature. Within the heterogeneous population of children with DCD, it is advised to use an individualized, specific skill intervention, which is expected to

be the most effective^{20,22,23,34}: what is trained is what will improve^{20,21,33}.

It is recommended that further investigation will be performed in order to determine the processes that underlie DCD. This theoretical framework can then be used to formulate how an intervention relates to causes and consequences.

In future investigations it is advisable to respect the internationally DSM-IV-criteria for DCD when setting up inclusion- and exclusion criteria for the research population. When confirming to these criteria, the research population becomes more and more clear, which strengthens the conclusions of the study involved.

When the effectiveness of a physiotherapeutic or occupational therapy intervention is being evaluated, it is recommended to use a standardized and internationally accepted outcome measure (e.g. Movement Assessment Battery for Children, Test of Gross Motor Development or Bruininsk-Oseretsky Test of Motor Proficiency or Concise Assessment Scale of Children's Handwriting). By using such an outcome measure, analysis of effects of interventions between studies becomes more transparent.

Furthermore, the need for high quality studies into the intervention effects of the different specific skill interventions, with a large population, is crystal clear after this review.

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