Physical Therapy Management of Children with Developmental Coordination Disorder

An Evidence-Based Clinical Practice Guideline from the Academy of Pediatric Physical Therapy of the American Physical Therapy Association

Supplemental Digital Content

Supplemental tools can be downloaded from the APPT website (https://pediatricapta.org/clinical-practice-guidelines)

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Table of Contents

Preface **1**

Search Strategy, Appraisals and Review **1**

Supplemental Digital Content Table 1: Search Terms *1*

Supplemental Digital Content Figure 1: Prisma Flow Chart *2*

Supplemental Digital Content Table 2: Operational Definitions and Outcome Measure Descriptions *3*

Supplemental Digital Content Table 3: ICF and ICD-10 Codes *4*

Action Statements with Supplemental Digital Content **6**

Action Statement 3: COMPLETE PARTICIPATION OUTCOME MEASURES. **6**

Description of Participation Outcome Measures: *6*

Canadian Occupational Performance Measure (COPM) 6

Goal Attainment Scale (GAS) 6

Perceived Efficacy and Goal Setting Program (PEGS) 6

Children's Assessment of Participation and Enjoyment (CAPE) and Preferences for Activities of Children (PAC) 6

Supplemental Digital Content Table 4: Participation and Goal Related Outcome Measures *7*

Action Statement 5: EXAMINE ACTIVITY LIMITATIONS USING QUESTIONNAIRES. **7**

Description of Questionnaires used to Examine Activity Limitations: *7*

Developmental Coordination Disorder Questionnaire 2007 (DCDQ'07) 7

Movement Assessment Battery for Children- 2nd edition Checklist (MABC-2-C) 7

Questionnaires or Interviews 7

Supplemental Digital Content Table 5: Summary of Questionnaires to Measure Activity Limitations (Criteria B) *8*

Action Statement 6: EXAMINE MOTOR PERFORMANCE USING STANDARDIZED MEASURES. **9**

Description of Standardized Measures for Motor Performance: *9*

Movement Assessment Battery for Children- Second Edition (MABC-2) 9

Bruininks-Oseretsky Test of Motor Proficiency- 2nd edition (BOT-2) 9

Supplemental Digital Content Table 6: Summary of Standardized Assessment Tools to Identify Motor Impairments (Criteria A) *9*

Action Statement 7: EXAMINE BODY FUNCTIONS AND STRUCTURES. **10**

Supplemental Digital Content Table 7: Component of Physical Fitness *10*

Supplemental Digital Content Table 8: Measures for Body Functions and Structures Used in the DCD Literature *10*

Action Statement 8: PROVIDE TASK-ORIENTED INTERVENTIONS COMBINED WITH RELATED BODY FUNCTIONS AND STRUCTURES INTERVENTIONS AS THE FIRST-CHOICE INTERVENTION. **10**

Description of Task-Oriented Interventions: *10*

Motor Skill Training (MST) 10

Neuromotor Task Training (NTT) 11

Cognitive Orientation to Daily Occupational Performance (CO-OP) 11

Motor Imagery (MI) 11

Description of Body Functions and Structures Interventions: *12*

Core Stability Training (CST) 12

Cardiorespiratory Training (CRT) 12
Functional Movement-Power Training Program (FMPT) 12
Supplemental Digital Content Table 9: Task-Oriented and Body Functions and Structures Interventions 12

Action Statement 10: RECOMMEND SUPPLEMENTAL ACTIVITIES TO AUGMENT THE FIRST-CHOICE INTERVENTION. 13

Descriptions of Supplemental Activities: 13
Soccer Training (Favor with trained coach) 13
Taekwondo (TKD) (Favor with reservation about direct impact on function) 13
Other Physical Activities in the Community (Favor) 13

General Guideline Implementation Strategies 13

Summary of Research Recommendations 14

Development of the Guideline 15

CAT-EI Appraisers: 15

Advisory Panel: 16

External Content Reviewers: 16

Acknowledgements: 16

Supplemental Digital Content Evidence Tables 10 - 14 17

Supplemental Digital Content Evidence Table 10: Systematic Reviews of Test and Measures for Children with DCD .. 17

Supplemental Digital Content Evidence Table 11: Systematic Reviews/Meta-analysis of Interventions for Children with DCD 18

Supplemental Digital Content Evidence Table 12: Task-Oriented Intervention Studies for Children with DCD 21

Supplemental Digital Content Evidence Table 13: Supplemental Intervention Studies for Children with DCD 26

Supplemental Digital Content Evidence Table 14: Prognostic Studies for Children with DCD 30

Preface

The following is provided as a supplement to the content in the Physical Therapy Management of Children with Developmental Coordination Disorder Clinical Practice Guideline (DCD CPG). Citations for references in the supplemental digital content are located in the DCD CPG. Readers are advised to refer to both documents for explanations, and to share both documents if forwarding the DCD CPG to other colleagues. Comments are welcome and may be sent to dcdguidelines@gmail.com.

Search Strategy, Appraisals and Review

The search strategy, search terms (Supplemental Digital Content Table 1), selection criteria, appraisal process,[20–22] data extraction, external review procedures and the Agree II[21] review are as follows.

The literature search was conducted by a medical research librarian (Lilian Takahashi Hoffecker, MS, MLS, PhD, University of CO, Anschutz Medical Campus) in the following databases: MEDLINE, PsycINFO, Embase, CINAHL, the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials and PEDro. The initial search was conducted September 2014, updated 6 times with refinements, with a final search January 2019. A Prisma flow chart is available as Figure 1.

Search criteria included concepts related to DCD, physical therapy management, children (5 -18 years), publication since 2010 (year that the first EACD guideline ended article inclusion)[15] and all study designs. Exclusion criteria included: studies focused on cerebral palsy, Down syndrome, autism or intellectual disability without the additional focus on DCD; publication types such as conference abstracts, dissertations, news, editorials, and letters; non-English articles; and those with no statistical analysis of results. Review articles and examination manuals were used to support recommendations for which limited experimental studies exist.

The concepts of "developmental coordination disorder" and "physical therapy management," and their relevant search terms, both text words and subject headings, are shown in Table 1. Search terms were truncated with wildcards to capture spelling variations while proximity syntax in databases that allow them, helped to retrieve adjacent or nearby words.

Supplemental Digital Content Table 1: Search Terms

Concept of Developmental Coordination Disorder		Concept of Physical Therapy Management	
apraxia; clumsiness; clumsy child syndrome; coordination disorder; developmental coordination disorder; discoordination; dyspraxia;	hypotonia; low tone; motor disorder; motor skills disorder; psychomotor disorder; sensorimotor disorder	balance; coordination intervention; endurance; exercise; fitness intervention; group intervention; motor control; motor learning; motor skills intervention; muscle strength; musculoskeletal manipulations; neurodevelopmental training;	occupational therapy; physical therapy; psychomotor performance; recreation therapy; recreational intervention; resistance training; sensory integration therapy; sports for persons with disabilities; sports intervention; strength training

Selection Criteria

After duplicates were removed from the 2014-2019 search, 2697 articles remained, with an additional 13 articles added from review of article reference lists. Titles of the 2710 articles were screened by at least 2 GDG members to remove irrelevant articles (n = 2091). The remaining 619 articles were screened by abstract by 2 GDG members for studies meeting the following criteria: they included children at risk for DCD, with a diagnosis of DCD, and studies that informed PTs' management of children with DCD. This resulted in 74 articles identified as relevant to the CPG. Research designs included CPGs, systematic reviews, randomized controlled trials (RCTs), cohort, case-control, case series and case studies.

Study Appraisals and Data Extraction Process

Data was extracted and verified from full-text articles by combinations of 2 GDG members from 24 examination articles, 31 intervention articles, 17 systematic reviews and 2 CPGs. The 74 articles were assessed further for quality and applicability, resulting in 57 articles that underwent appraisal. Volunteer literature appraisers, solicited through APPT conferences and social-media, received on-line training and reliability testing to use the APTA's Critical Appraisal Tool for Experimental Intervention Studies (CAT-EI).[20] Volunteers qualified with >90% agreement with test article keys. Appraisers were randomly paired to read the 31 intervention and 7 examination articles, compare scores for agreement and submit a single critical appraisal form when complete. Discrepancies in scoring were resolved via discussion by the readers. If a score could not be agreed on, a GDG member made the final determination.

Clinical practice guidelines and systematic reviews (SRs) were appraised by different combinations of the GDG members using the AGREE II tool[21] and the AMSTAR checklist.[22] After exclusion for evidence quality, a total of 41 appraised articles were used in this CPG. See Supplemental Digital Content Evidence Tables 10-14 at the end of the document.

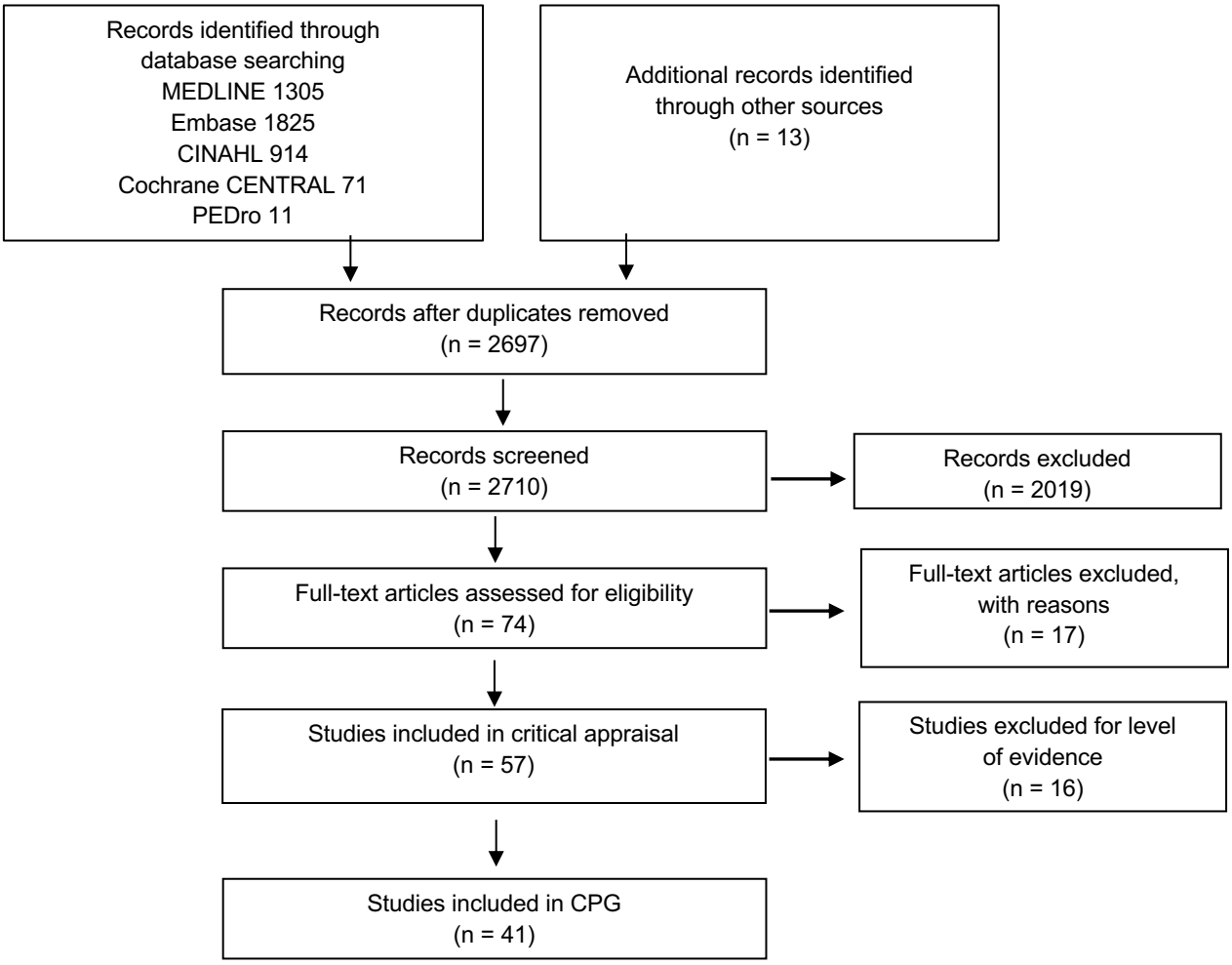
External Review Procedures

A first draft of the 2020 DCD CPG was reviewed by 11 stakeholders representing medicine, psychology, occupational therapy, educators and a parent of a child with DCD, and PTs representing practice, research, and knowledge translation. Both a rating scale to assess clarity and implementation feasibility as well as open-ended invitation for comments and edits were used to gather feedback. Of the 13 statements, over 90% were rated as clear and feasible. After addressing the first round suggested edits, the document was reviewed by a member of the American Academy of Pediatrics (AAP) and posted for public review on the APPT website; invitations to review were distributed to APPT members via its electronic newsletters and through a social media posting. Non-members could review if notified by APPT members. Suggested edits were addressed, and the final draft was submitted to the Pediatric Physical Therapy Journal for editorial review. Modifications based on comments from the reviews addressed language consistency, inclusion of culture, and clarity of parent preferences. Some reviewers requested production of parent, PT, and healthcare provider support documents.

AGREE II Review

This CPG was evaluated by 3 external reviewers using AGREE II.[21] Domain scores for the DCD CPG ranged from 81% to 100%. The 3 reviewers agreed to recommend this “excellent” guideline for use. Scores were discussed by the GDG; where possible, lower scoring items were addressed in the final CPG manuscript.

Supplemental Digital Content Figure 1: Prisma Flow Chart



Supplemental Digital Content Table 2: Operational Definitions and Outcome Measure Descriptions

Terminology	Operational Definitions
Child with coordination difficulties	A general term used to describe a child who appears clumsy or awkward and has difficulties learning to coordinate movement.
DCD	Children meeting all criteria of the DSM-5. Children in this category typically score at or below the 5th percentile on the MABC-2[38] or less than 42 (1.5 standard deviations) on the BOT-2.[86]
Exclusionary Conditions	Difficulties in motor performance which are secondary to intellectual disability (intellectual developmental disorder), visual impairment or other neurological conditions (e.g., cerebral palsy, muscular dystrophy, degenerative disorder).
Lack of coordination	This term is used for billing purposes for ICD-10 coding (Supplemental Digital Content Table 3).
At risk for DCD	Also described as having movement difficulty that requires monitoring, children in this category score between the 6th and 15th percentile on the MABC-2.[38]
Suspect for DCD	Children who have a low score on the DCDQ'07.[56]
Probable DCD	Also described as having significant movement difficulty, children in this category score at or below the 5th percentile on the MABC-2.[38]
Supplemental activities	Activities that PTs may recommend to augment first-choice interventions.

ICF Level	Outcome Measure	Description
Body Structure/ Function	6-minute walk test (6MWT)	Submaximal exercise test to assess aerobic capacity and walking endurance.
	20-meter Shuttle Run Test (20mSRT)	Multi-stage testing consisting of continuous running between two lines, 20 meters apart to assess cardiorespiratory endurance.
	Progressive Aerobic Cardiovascular Endurance Run (PACER)	Multi-stage testing consisting of continuous running between two lines, 20 meters apart to assess cardiorespiratory endurance.
	Functional Strength Measure (FSM)	Measures muscular strength and endurance through eight standardized functional tasks.
	Lafayette Hand-held Dynamometer	Ergonomic hand-held device for objectively quantifying muscle strength.
	Muscle Power Sprint Test (MPST)	Anaerobic field test consisting of six, timed 15 m sprints.
	Sensory Organization Test (SOT)	A form of posturography that quantitatively assesses the visual, proprioceptive and vestibular cues to maintain postural stability in stance.
Activity / Participation	BOT-2	Measures gross and fine motor skills.
	TGMD-2 (TGMD-3 now available)	Measures gross motor skills, specifically fundamental motor skills needed to develop sport-specific skills.
	MABC-2	Measures balance, gross motor and fine motor skills.
	Goal Attainment Scaling (GAS)	Criterion-referenced, individualized goal-based outcome measure that tracks an incremental change in performance.
	Canadian Occupational Performance Measure (COPM)	Standardized outcome measure designed for use by occupational therapists. May also be used by multidisciplinary teams that include PT. Identifies and detects changes in a child's self-perception of performance in meaningful everyday activities.
	Perceived Efficacy and Goal Setting system (PEGS)	Standardized self-efficacy measure that examines a child's self-report of their perceived competence in 24 everyday tasks in their home, school and community environments.
	Children's Assessment of Participation and Enjoyment (CAPE) and Preferences for Activities of Children (PAC)	Standardized self-report measures of children's participation in recreation and leisure activities outside of mandated school activities. The CAPE and PAC are companion measures and are typically used together.

Additional outcome measures organized by the ICF model can be found in a fact sheet by the Academy of Pediatric Physical Therapy.[98]

Supplemental Digital Content Table 3: ICF and ICD-10 Codes

ICF Codes		DCD Presentation
Impairments of Body Functions and Structures		
b156	Perceptual functions: specific mental functions of recognizing and interpreting sensory stimuli	Difficulty coordinating various stimuli inputs to modify motor task
b1646	Problem solving mental functions of identifying, analysis, and integrating incongruent or conflicting information into a solution	Difficulty with modifying motor responses to situational experiences
b2100	Visual acuity functions	Difficulty in discriminating shape, size, color and other ocular stimuli.
b4550	General physical endurance	General fatigue, lower tolerance to activity
b620	Proprioceptive function	Difficulty with spatial organization
b7108	Mobility of joint functions, other specified	Joint laxity
b7300	Power of isolated muscles and muscle groups	Weakness
b7350	Tone of isolated muscles and muscle groups	Hypotonia
b7400	Muscle functions, other specified and unspecified	Diminished endurance
b755	Involuntary movement reaction functions	Involuntary contractions of large muscles or the whole body induced by body position and balance
b7600	Control of simple voluntary movements	Poor coordination; difficulty with multi-sequence tasks
b7700	Gait pattern functions	Muscle co-contraction and joint stabilization
b7800	Sensations related to muscles and movement functions	Predominant use of vision to guide motor actions
b7890	Movement functions, other specified and unspecified	Failure to transfer and generalize motor tasks to new activities or contexts; reduced efficacy of the feedback & feedforward motor control mechanism
Activity Limitations		
d175	Solving problems	Difficulty selecting the most efficient or effective movements in order to complete a task
d177	Involuntary movement reaction functions	Unsteadiness during activities secondary to atypical postural reactions, righting reactions, balance reactions, etc.
d220	Undertaking multiple tasks	Difficulty with multi-sequence tasks
d415	Maintaining a body position	Inability to stand or sit still in a chair without frequent fidgeting
d429	Changing and maintaining body position, other specified and unspecified	Delayed and reduced quality of fine and gross motor skills (hopping, jumping, ball skills, and writing)
d4341	Kicking	Poor form, aim, distance, height of kick
d450	Walking	Awkward, slow uncoordinated gait pattern
d453	Running	Awkward, slow, loud, uncoordinated running pattern
d4454	Throwing	Immature form, aim, distance of throw
d4455	Catching	Immature catching pattern with limited coordination with eyes to follow direction of ball
d469	Walking and Moving, other specified and unspecified	Variability in movement quality (speed, timing, force, distance)
Participation Restrictions		
d230	Carrying out daily routine	Difficulty independently participating in daily requirements, may require frequent redirection to task
d7600	Parent-child relationships	Parent knowledge and understanding of diagnosis and impact on participation
d7601	Child-parent relationships	Child's difficulty with being able to follow through with parent instructions, routines and general participation with family activities
d720	Complex interpersonal interactions	Age matched interactions can be diminished due to ability to participate in age appropriate activities
d835	School life and related activities	Delayed educational success leading to being held back in school; difficulty participating in recess and other extracurricular activities
d859	Work and employment, other specified and unspecified	Diminished ability to participate in employment requirements
d920	Recreation and leisure	Difficulty participating in age appropriate activities, particularly group tasks

Supplemental Digital Content Table 3: ICF and ICD-10 Codes continued

F82 Specific developmental disorder of motor function
**This code is offered for reference and is not intended to be directional for billing purposes*

F82 Type 1 and Type 2 exclusions. Type 1 exclusions can never be used in conjunction with the F82 code and they include: Abnormalities of gait and mobility (R26.-) and Lack of coordination (R27.-). Type 2 exclusions may be used with the F82 code though only if both diagnoses are present. The type 2 exclusion is Lack of coordination secondary to intellectual disabilities (F70-F79).

This GDG is aware that historically PTs may have used codes to represent body structure and function deficits present in children with lack of coordination or probable DCD. These codes may have included:

R26.2:	Difficulty in walking, not elsewhere classified
R26.8:	Other abnormalities of gait and mobility
R26.81:	Unsteadiness of feet
R26.89:	Other abnormalities of gait and mobility
R26.9:	Unspecified abnormalities of gait and mobility
R27:	Other lack of coordination
R27.9:	Unspecified lack of coordination

Physical therapists should use the F82 code when treating a child with lack of coordination secondary to a probable or formal DCD diagnosis and should not use the R26- or R27- codes in this case.

Action Statements with Supplemental Digital Content

I. Physical Therapy Examination and Referral of Children with Coordination Problems, at risk for or Diagnosed with DCD

Action Statement 3: COMPLETE PARTICIPATION OUTCOME MEASURES.

Description of Participation Outcome Measures:

Canadian Occupational Performance Measure (COPM)

The COPM is a standardized outcome measure for children 8 years old and older with developmental delays that can be used across a variety of clinical settings.[47] It takes 20 to 40 minutes to administer and measures a child's or parent/caregiver's perceived performance change or satisfaction with the child-chosen goal before and after intervention. Change is scored using a visual analog scale from 1 to 10 (higher scores indicate better performance or greater satisfaction). A 2-point change is considered clinically meaningful.[47] The COPM was designed to assess individual perceived performance in self-care, productivity and leisure. Responsiveness, validity and reliability of the COPM are reported to be satisfactory to excellent.[47] **(Evidence Quality: II-III; Recommendation Strength: Moderate)**

Goal Attainment Scale (GAS)

The GAS is a criterion-referenced, individualized goal-based outcome measure that tracks the degree to which the expected level of performance change in the task or behavior is achieved.[48] Measurable and meaningful criteria for change are scored using a 5-point interval scale, reflecting a change from baseline. The GAS can be used for all ages, regardless of disability, across multiple clinical settings. Outcomes scores should be calculated periodically to determine intervention effectiveness and progress towards individualized goals. The GAS scores are converted to aggregated T-scores to determine if significant changes occurred. Reliability of GAS is largely unknown and training is suggested to increase reliability. The GAS has ambiguous validity although literature using the GAS exists across many populations. The GAS has acceptable responsiveness and sensitivity to change for children with a variety of developmental conditions.[49] It is unclear at which age children can reliably contribute to this measure, but parents/caregivers can contribute to establishing goals.[49] **(Evidence Quality: V; Recommendation Strength: Best Practice)**

Perceived Efficacy and Goal Setting Program (PEGS)

The PEGS is a standardized self-efficacy measure for children chronologically or developmentally 5 to 9 years old with developmental delays that can be used across a variety of clinical settings.[39] It was partially developed to fill the gap from the COPM, which is recommended for children 8 years and older. It takes 20 to 30 minutes to administer and examines a child's self-report of perceived competence in 24 everyday activities in 3 categories: self-care, school/productivity, and leisure; together serving as a participation proxy measure. A higher score indicates greater self-efficacy. Results inform priorities for the child's intervention and the parent/caregiver's perspective of the child's needs. The instruction manual reports content validity with the School Function Assessment ($p < .01$) and the BOTMP ($p < 0.0001$), internal consistency (alpha coefficient of 0.91), test-retest reliability ($r = 0.77$), and goal stability (69 to 92%).[39] The manual concludes that the PEGS validity and reliability is satisfactory for clinical use to assist children in participating in the goal-setting process.[39] **(Quality: V; Recommendation Strength; Best Practice)**

Children's Assessment of Participation and Enjoyment (CAPE) and Preferences for Activities of Children (PAC)

The CAPE and PAC are standardized 55-item questionnaires for children 6 to 21 years of age with and without disabilities, used across a variety of clinical settings.[50] The CAPE examines 5 participation dimensions outside of school classes: number of activities, participation frequency, enjoyment, with whom and where activities occur. The PAC adds a 6th dimension on activity preferences. An overall participation score is given as well as separate scores for diversity, intensity, enjoyment, with whom, where and activity preference. The CAPE and PAC allow the child to be an active participant in goal setting and intervention. The CAPE and PAC can measure intervention effectiveness if participation improvement is a goal. However, the 2004 manual states that caution should be used in practice until further reliability and validity studies are published.[50] **(Evidence Quality: II-V; Recommendation Strength: Weak)**

Supplemental Digital Content Table 4: Participation and Goal Related Outcome Measures

Test	Description	Age	Time	Population	Cost
COPM[47]	Standardized outcome measure designed for use by occupational therapists. May also be used by multidisciplinary teams that include PT. It identifies and detects changes in a child's self-perception of performance in meaningful everyday activities .	8 years and older	20 to 40 minutes	Children with developmental disorders or disabilities, multitude of settings	$
GAS[48]	Criterion-referenced, individualized goal-based outcome measure that tracks an incremental change in performance	Any age	Varies	Children with and without disability, multitude of settings	Free
PEGS[39]	Standardized self-efficacy measure that examines a child's self-report of their perceived competence in 24 everyday tasks in their home, school and community environments.	5 to 9 years old	20 to 30 minutes	Children with developmental disorders or disabilities, multitude of settings	$
CAPE & PAC[50]	Standardized self-report measures of children's participation in recreation and leisure activities outside of mandated school activities. The CAPE and PAC are companion measures and are typically used together.	6 to 21 years old	CAPE: 30 to 45 minutes PAC: 15 to 20 minutes	Children with and without disability, multitude of settings	$

$, Under $500; $$, Under $1000; $$$, Greater than $1000; CAPE, Children's Assessment of Participation and Enjoyment; COPM, Canadian Occupational Performance Measure; GAS, Goal Attainment Scale; PAC, Preferences for Activities of Children; PEGS, Perceived Efficacy and Goal Setting System

Action Statement 5: EXAMINE ACTIVITY LIMITATIONS USING QUESTIONNAIRES.

Description of Questionnaires used to Examine Activity Limitations:

Developmental Coordination Disorder Questionnaire 2007 (DCDQ'07)

The DCDQ'07 is a free, standardized questionnaire for parents/caregivers to complete about their child's coordination in everyday functional activities using a 5 point Likert scale.[56] Fifteen items are organized into 3 factors: control during movement, fine motor and handwriting, and general coordination. The DCDQ'07 was developed to assist in the identification of children 5 to 15 years old with possible DCD. It is the questionnaire most often used in the literature to establish DSM-5 Criteria B (Participation and ADL Deficits) (Table 7) and has been recommended as the questionnaire of choice for clinical settings.[16] The DCDQ'07 should not be used in isolation to make a diagnosis of DCD but rather to support other tests and findings.[56,84] It has good sensitivity of 85%, lower specificity of 71% and a moderate correlation (r = .55) with the total score of the MABC (Version 1 and 2).[56] **(Evidence Quality I and V; Recommendation Strength: Moderate)**

Movement Assessment Battery for Children- 2nd edition Checklist (MABC-2-C)

A standardized questionnaire designed to identify children with movement difficulty that may be completed by teachers, parents, therapists and other professionals using a 4-point scale.[38] In a school setting, the questionnaire should be completed by the classroom or special education teacher. The MABC-2-C consists of 30 items to rate a child's motor competence in 2 sections (predictable and unpredictable environments) in the following categories: self-care skills, classroom skills, ball skills and physical education recreational skills.[19] A third section has 13 non-motor items that may affect movement. The MABC-2-C should not be used alone to diagnose DCD or other conditions but can support findings of a possible diagnosis. The MABC-2-C has a low sensitivity of 41% and good specificity of 88%. It has a moderate correlation with the total score of the MABC-2 (r=0.38) and the DCDQ-07 (r= 0.55).[38,84] This proprietary measure adds an additional service cost. **(Evidence Quality I and V; Recommendation Strength: Moderate)**

Questionnaires or Interviews

Questionnaires and interviews administered by the PT should be completed by caregivers, significant adults, and the child to document performance in everyday activities at home, school, and in the community. When standardized, these reports provide the PT with valuable information about the child's baseline ability to participate in multiple settings, may provide a method to clarify change, and take into account cultural and environmental contexts that other standardized tests may not be able to assess.[10,16,17,85] The data collected should include specific activities that are limiting the child's participation in meaningful life events. The activities may include self-care tasks, schoolwork productivity and play/recreational skills. **(Evidence Quality: V-expert opinion; Recommendation Strength: Best Practice)**

Supplemental Digital Content Table 5: Summary of Questionnaires to Measure Activity Limitations (Criteria B)

Test	Description	Age	Time	Population	Cost	Recommendation Strength
DCDQ'07[56]	Parent report measures developed to assist in the identification of DCD in children. It provides a standard method to measure a child's coordination in everyday functional activities. Contains 15 items in 2 domains: gross motor skills and fine motor skills	5 to 15 year old	10 to 15 minutes	Children with suspected movement disorders	Free	GDG first choice. Moderate
MABC-2[38]	A questionnaire designed to identify children who may have a movement disorder. Completed by teacher, parent, or therapist. Contains 30 items in 3 categories: self-care skills, classroom skills, and physical education/recreational skills	5 to 12 years old	10 minutes	Children with suspected movement disorders	$$$	Moderate
Questionnaires and Interviews	An interview process that may include the child and significant adults to determine if limitations in ADLs exist at home, school or within the community. Informal questionnaires contribute to a comprehensive evaluation to further define participation restrictions and activity limitations	Any age	UNK	All disability groups and developmental levels	Free	Best Practice
DCDDaily[57]	A standardized, objective instrument of capacity in ADL for children with suspected DCD. Contains 18 tasks in 3 domains: self-care and self-maintenance, productivity and schoolwork, and leisure and play	5 to 8 years old	< 30 minutes	Children with suspected movement disorders	Free	Needs further research with the DCD population
DCDDaily-Q[58]	Parent questionnaire identifies specific ADL difficulties for children with suspected DCD. The DCDDaily-Q may identify children with and without DCD. Contains 23 essential ADL is known to be difficult for children with DCD in 3 domains: self-care and self-maintenance, productivity and school, and leisure and play	5 to 8 years old	UNK	Children with suspected movement disorders	Free	Needs further research with the DCD population
SFA[59]	Criterion-referenced assessment of students' performance of functional tasks that supports their participation in the academic and social aspects of an elementary school program. Three sections are included: participation, task support and activity performance	K to 6th grade	10 to 120 minutes	Elementary students with various disabilities	$$	Needs further research with the DCD population

UNK, unknown; $, Under $500; $$, Under $1000; $$$, Greater than $1000; DCDQ'07, Developmental Coordination Disorder Questionnaire 2007; MABC-2-C, Movement Assessment Battery for Children Checklist; 2nd edition; SFA, School Function Assessment

Action Statement 6: EXAMINE MOTOR PERFORMANCE USING STANDARDIZED MEASURES.

Description of Standardized Measures for Motor Performance:

Movement Assessment Battery for Children- Second Edition (MABC-2)
The MABC-2 is a standardized norm-referenced assessment administered by the PT for children 3 to 16 years old with mild to moderate motor difficulties.[38] It takes 20 to 40 minutes to administer the test. A total of 8 items are assessed in 3 domains: manual dexterity, aiming and catching and balance. The items include both qualitative and quantitative tasks. A traffic light system describes the level of movement difficulty. A score less than or equal to the 5th percentile indicates significant movement difficulty (red zone), between the 5th to 15th percentile indicates at risk of having a movement difficulty (amber zone) or above the 15th percentile indicates no movement difficulty (green zone). These percentiles are used consistently in the literature as cut-off points that contribute to criteria A (motor performance deficits). However, PTs may also use the Total Test Score within the traffic light system to determine the degree of motor difficulty.[38] The MABC-2 does not assess general motor development (age equivalent) or ADL capacity.[10] It was designed to identify motor impairments. The psychometric qualities have been tested more than other measures in the DCD population.[16] It has good test-retest reliability (ICC=0.83–0.96) with evidence of predictive validity.[6] Minimal clinically important difference (MCID) of 1.39 and minimal detectable change (MDC) of 1.83 have been reported for the total test standard score, with satisfactory sensitivity and specificity.[6] These values should be used cautiously until further investigation is completed. A 2019 CPG for DCD recommended the MABC-2 over the BOT-2 based on quality and suitability,[16] though, a 2018 systematic review found that the BOT-2 had stronger test-retest reliability than the MABC-2.[6] **(Evidence Quality II-V; Recommendation Strength: Moderate)**

Bruininks-Oseretsky Test of Motor Proficiency- 2nd edition (BOT-2)
The BOT-2 is a standardized norm-referenced assessment administered by the PT to children 4 to 21 years old with motor difficulties.[86] The BOT-2 contains 53 items of motor performance in 4 areas: fine manual control, manual coordination, body coordination, and strength and agility. It takes 45 to 60 minutes to administer the long-form and 10 to 15 minutes for the short form (BOTMP-SF). The results generate a total motor composite score. A score <42 (1.5 standard deviations) has been recommended as a cut-off to identify probable DCD (BOT-2 manual). It has excellent test-retest reliability (ICC=0.80–0.99) with good to excellent validity.[6] Minimal clinically important difference (MCID) of 6.54 and minimal detectable change for the total motor composite score (MDC) of 4.18 and 7.43 values have been reported, with satisfactory sensitivity and specificity, but these values should also be used cautiously until further investigation is completed.[6] The BOT-2 was found to be the most valid assessment of motor difficulties for children12 years and older (young adults).[89] **(Evidence Quality II-V; Recommendation Strength: Moderate)**

Supplemental Digital Content Table 6: Summary of Standardized Assessment Tools to Identify Motor Impairments (Criteria A)

Test	Description (Evaluative)	Discriminative	Age	Time	Population	MCID for Composite Scores	MDC for composite scores	Normative Sample Population	Cost	Recommendation Strength
MABC-2[38]	Measures balance, gross and fine motor skills.	Differentiates children with DCD from typically developing children.	3 to 16 yo	20 to 40 mins	mild to moderate gross motor delays	1.39 for total test standard score [6]	1.83 for total test standard score [6]	UK population	$$$	Recommended by GDG Moderate
BOT-2[86]	Measures gross and fine motor skills.	Differentiates children with DCD from typically developing children.	4 to 21 yo	40 to 60 mins	mild to moderate gross motor delays	6.54 for total motor composite score [6]	4.18 for total motor composite score [6]	USA population	$$$	Recommended by GDG Moderate
TGMD-2[90] TGMD-3[91]	Measures gross motor skills, specifically fundamental motor skills needed to develop sport-specific skills.	Differentiates children with cognitive impairments and autism spectrum disorder from typically developing children.	3 to 10 yo	15 to 20 mins	mild to moderate gross motor delays			USA population	$	Needs further research with the DCD population.

$: Under $500, $$: Under $1000, $$$: Greater than $1000, BOT-2, Bruininks-Oseretsky Test of Motor Proficiency- 2nd edition; MABC-2, Movement Assessment Battery for Children- Second Edition; mins, minutes; TGMD-2, The Test of Gross Motor Development -2nd Edition; TGMD-3, The Test of Gross Motor Development-3rd Ed; yo, years old.

Action Statement 7: EXAMINE BODY FUNCTIONS AND STRUCTURES.

Supplemental Digital Content Table 7: Component of Physical Fitness

Health Related Components	Skill Related Components
• Muscular Endurance • Muscle Strength • Cardiorespiratory Fitness • Flexibility • Body Composition	• Agility • Balance • Coordination • Reaction Time • Speed • Power

Components of physical fitness[97]

Supplemental Digital Content Table 8: Measures for Body Functions and Structures Used in the DCD Literature

Health Related Components of Physical Fitness

Body Functions/Structures	Assessment Tool	Description	Age	Cost
Cardiorespiratory Fitness Muscle Endurance	6MWT[77]	Submaximal exercise test to assess aerobic capacity and walking endurance.	3 to 18 years old	Free
Cardiorespiratory Fitness	20mSRT[95] OR PACER [70,71,76,96]	Multi-stage testing consisting of continuous running between two lines, 20 meters apart to assess cardiorespiratory endurance (Leger et al., 1988). Reference values published in Tomkinson et al., 2017. FITNESSGRAM has a table with laps needed for students to achieve the Healthy Fitness Zone®	9 to 17 years old	Free
Muscular Strength Muscular Endurance	FSM[71]	Measures muscular strength and endurance through eight standardized functional tasks.	4 to 10 years old	$
Muscular Strength	Hand-held Dynamometer[71]	Ergonomic hand-held device for objectively quantifying muscle strength Reference values and methods: Hébert, Luc J et al., 2015	4 to 17 years old	$$

Skill Related Components of Physical Fitness

Body Functions/Structures	Assessment Tool	Description	Age	Cost
Muscle Power	MPST[70,71]	Anaerobic field test consisting of six, timed 15 m sprints. (Verschuren et al.,2007, Riet DD, 2012) Reference values established for typically developing children (Riet DD, 2012) and children with cerebral palsy (Verschuren et.al, 2007)	6 to 12 years old	Free
Balance	SOT[60–62,66,78]	A form of posturography that quantitatively assesses the visual, proprioceptive and vestibular cues to maintain postural stability in stance.		$$$

$: Under $500, $$: Under $1000, $$$: Greater than $1000, 6MWT, 6-minute walk test; 20mSRT, 20-meter shuttle run test; FSM, Functional Strength Measure; MPST, muscle power sprint test; PACER, Progressive Aerobic Cardiovascular Endurance Run; SOT, Sensory Organization Test

II. Physical Therapy Intervention for Children at Risk for or Diagnosed with DCD

Action Statement 8: PROVIDE TASK-ORIENTED INTERVENTIONS COMBINED WITH RELATED BODY FUNCTIONS AND STRUCTURES INTERVENTIONS AS THE FIRST-CHOICE INTERVENTION.

Description of Task-Oriented Interventions:

Motor Skill Training (MST)

Based on the theories of motor control and motor learning that requires practice and repetition of voluntary body movements to accomplish a specific motor skill goal.[100,101] Over time, the complexity and difficulty of the tasks are modified. The goals of motor skills training are to resolve, reduce, or prevent impairment; develop effective and efficient strategies to accomplish functional goals; and to adapt functional goals to environmental conditions to maximize participation.[100] Motor skills training is the term used by the GDG for interventions that meet the above definition. The DCD literature contains multiple descriptive terms for motor skills training using a task-oriented approach, including functional movement training (FMT),[61,62] specific task-oriented interventions,[63,70,78] task-specific interventions,[65,70] and motor skills training.[75,79,81,83]

Motor skills training includes a variety of methods to improve motor performance for children meeting the criteria for DCD or diagnosed with DCD, aged 5 to 12 years old. Large effect sizes (Cohen's d= 0.96,[7] Hedges' g=.62,[5]) were reported from many

high quality systematic reviews using the MABC (version 1 or 2) as a primary [63,76,78,81] or secondary [61] outcome measure to determine the effects on motor performance. Motor skills training also had a positive effect on physical fitness components of balance,[61,62,78] cardiorespiratory fitness [71,76,77] and functional muscle strength.[71,81] However, motor skill training (running, walking, and balance skills) performed in a pool (aquatic therapy), provided by a PT for 6 weeks, did not show a significant change on the posttest MABC results.[79] Several systematic reviews concluded that aquatic therapy was potentially an ineffective intervention for improving motor performance for children with DCD,[5,8,12] but it was not clear whether the intervention dosage was a factor. Overall, land based motor skills training is an effective task-oriented approach to improve motor performance and components of physical fitness (Table 16). **(Evidence Quality: I; Recommendation Strength: Strong)**

Neuromotor Task Training (NTT)

A task-oriented approach, developed in the Netherlands, based on the theories of motor control and motor learning for children at risk for or diagnosed with DCD.[7,103] NTT uses task analysis to simplify a skill (gross or fine motor) into smaller components based on the child's capabilities. Once divided into smaller components, the environment and task demands are lessened to promote task success. The environmental and task demands are subsequently increased until the child generalizes skills to perform and meet the goal successfully. Smits-Engelsman et al., concluded that "activity-oriented approaches (like NTT) that focus on task-specific skills showed consistent improvements not only on activity-based outcomes but also on body function."[7, pg.96] NTT intervention was examined on children 6 to 10 years old at risk for DCD to determine the effects on motor performance using 45-60 minute sessions, 2x/week for 9 weeks.[71] Participant goals were to improve playing outdoor games with others such as soccer and tag. Stations were set up to practice specific skills related to the games under the PT's supervision, who modified the tasks and environment as needed. A significant improvement in motor performance was found on the MABC-2 with a large effect size (Cohen's d = 2.30, 95% CI [1.69, 2.84]).[7,71] NTT was highly recommended as an intervention to improve motor skills by Preston et al.'s systematic review (Table 16).[8] **(Evidence Quality: I; Recommendation Strength: Strong)**

Cognitive Orientation to Daily Occupational Performance (CO-OP)

A "client-centered, performance-based, problem-solving approach that enables skill acquisition through a process of strategy use and guided discovery."[105] CO-OP was developed in Canada in the early 1990s by Dr. Polatajko, an OT using behavioral and cognitive learning theories, as well as principles of motor control and motor learning, and has been used with children with DCD. Earlier literature referred to CO-OP as a "cognitive approach" to improve occupational performance.[106,107] It was designed to be multidisciplinary as it includes principles of educational and behavioral psychology, health, human movement science, and occupational therapy.[105] CO-OP uses a 4-step self-instructional problem-solving strategy. This method is typically summarized with the mnemonic "GOAL-PLAN-DO-CHECK" [105,107] translated as the Goal: "What do I want to do?," the Plan: "How am I going to do it?," the Do: "Do it!" and the Check: "How well did my plan work?" Additional training is required to correctly administer the intervention to incorporate the 6 components of the therapeutic intervention: client chosen goals, dynamic performance analysis, cognitive strategy use, guided discovery, enabling principles, and parent/caregiver involvement as part of the intervention format.[105]

CO-OP interventions were examined to determine its effects on motor proficiency, psychosocial domains, and participation for children diagnosed with DCD or probable DCD, ages 7 to 12 years old, in 4 studies.[67,69,72,74] In each study, children chose goals related to object manipulation (ball skills, writing, scissor use),[67,74] riding a bike [67] or traversing monkey bars.[67] The CO-OP approach did not produce significant improvements in motor performance based on the MABC-2 (Cohen's d=0.22),[5,74] or increased willingness to participate in physical activity based on the Children's Assessment of Participation and Enjoyment (CAPE).[67] However, children and parents reported positive changes in perceived performance and satisfaction [67,74] using the Canadian Occupational Performance Measure (COPM)[47] with a large effect size (Cohen's d=2.16 and 2.40 respectively).[7] A significant improvement was found on Goal Attainment Scales (GAS) for targeted goals, with a large effect size (Cohen's d=1.98)[7] when compared to no intervention.[74] Jokic et al. used the CO-OP approach to study self-regulation over time through observation[69] and concluded that a possible link exists between improved task performance and improved self-regulatory performance in children 7 to 9 years old with DCD. A similar study by Hyland et al.,[72] found positive results in self-regulation for children 7 to 12 years old using the CO-OP approach compared to a contemporary treatment approach (process-oriented approach combined with functional training) and task specific intervention. Due to limited studies and small sample sizes of children with DCD, more evidence is needed to determine the effectiveness of CO-OP on motor performance and participation in physical activities.[108] These initial studies provide encouraging findings for the CO-OP approach as an intervention for the DCD population to achieve targeted goals, improved self-regulation, and positive parent/child reports on performance and satisfaction (Table 16). **(Evidence Quality: I - III; Recommendation Strength: Moderate)**

Motor Imagery (MI)

A mental process by which an individual rehearses or simulates a given action.[104] Wilson et al. describes MI as a protocol with 6 components: 1) visual imagery exercises, 2) relaxation and mental preparation, 3) visual modeling of fundamental motor skills, 4) mental rehearsal of skills from an external perspective. 5) mental rehearsal of skills from an internal perspective, and 6) overt practice with repetitions of the skill and mental rehearsal between each skill.[104] Motor Imagery was examined with children 7 to 12 years old at risk for DCD (<10th percentile on the MABC) in 3 different training conditions; MI training (n=12), perceptual-motor training (PMT) (n=13) and a wait-list control group (n=11).[104] The MI group practiced fundamental motor skills presented in a digital video and modeled by peers who were considered well-coordinated for their age. The PMT group practiced various fine, gross, and perceptual-motor skills tailored to meet the individual child. The MI and PMT protocols were implemented through 5 individual 60 minute weekly sessions. The results showed that MI (r=0.84) and PMT (r=0.74) were equally effective in improving motor performance, with moderate-to-large effect sizes,[104] as compared to the control group. Motor imagery has been strongly

recommended as an intervention to improve motor performance in a systematic review by Preston et al.[8] and was included in the meta-analyses for task-oriented interventions that positively affect motor performance for children with DCD (Table 16).[5,12] **(Evidence Quality: I; Recommendation: Moderate**

Description of Body Functions and Structures Interventions:

Core Stability Training (CST)

An intervention at the ICF level of a body functions and structures used to improve the muscle strength of the abdominal and lumbopelvic region.[78] A core stability training program, using a physioball, was compared to a task-oriented intervention to determine motor performance change using the BOT-2 and balance change using the Sensory Organization Test (SOT).[78] Children, 6 to 9 years old at risk for DCD, participated in the intervention groups for 8 weekly 60-minute sessions. The core stability training group performed stability exercises using the physioball in the supine, prone, sitting and standing positions. The task-oriented training group focused on functional tasks which included walking, running, jumping, hopping, skipping and galloping. The interventions resulted in significant improvements in motor performance for both groups with a large effect size (Cohen's d=0.84); there was no statistical between-group difference.[78] Preston et al. concluded that CST alone could be used with moderate confidence to improve motor performance based on the effect size and associated 95% confidence interval (0.31 to 2.13).[8] However, the task-oriented intervention group demonstrated a significantly increased composite equilibrium score on the SOT (p=0.008) while the core stability group did not reach a level of significant change (p=0.812).[78] The SOT primarily assesses standing balance. This could be explained by the activities performed in each group. The core stability group focused on exercises using a physioball with few exercises in standing. The task-oriented group performed all activities in standing with an emphasis on functional skills. Therefore, if the goal is to improve motor performance, core stability training may be used. But to capture the additional benefit of improved balance, dynamic functional tasks should be used as part of the intervention (Table 9). (Evidence Quality: **II**; Recommendation: **Moderate**)

Cardiorespiratory Training (CRT)

An intervention at the level of body functions and structures to improve cardiorespiratory fitness (Table 16). Tsai et al. examined the effects of a cardiorespiratory (endurance) training program with children 11 to 12 years old at risk for DCD compared to 2 non-training groups of children; one who were typically developing and one at risk for DCD.[76] The children in the training program completed rigorous interval training with running, long-distance running and aerobic activities (cycling, step aerobics, jump roping). The 50 minutes sessions supervised by an adapted physical education teacher were performed 3 times a week for 16 weeks at school. Two high quality meta-analyses confirmed a significant improvement in motor performance on the MABC-2 composite score with a large effect size (Cohen's d=2.68,[7] Hedges' g=2.45[5]). A significant improvement in cardiorespiratory fitness was also found on the Progressive Aerobic Cardiovascular Endurance Run test (PACER).[76] (Evidence Quality: **II**; Recommendation: **Moderate**)

Functional Movement-Power Training Program (FMPT)

Combines a task-oriented approach using functional movement training (FMT) to improve balance and coordination with power/resistance training.[62] The effects of FMPT, FMT, and no training were compared to determine the effects on balance and neuromuscular performance with children 6 to 10 years old with DCD. The FMT program included task-specific exercises modified from the balance section of the MABC with electromyographic biofeedback. During the sessions, the FMPT group also completed power/resistance training after the FMT program completed by both groups.[62] The FMPT program focused on large lower extremity muscle groups to improve strength, power, and speed. A 1 repetition maximum was used to determine the intensity, which was adjusted each month. The FMT and FMPT training programs were implemented for 1.5-hour sessions 2 times a week for 12 weeks, supervised by a PT and carried out by a trained research assistant. The FMPT group demonstrated improved balance strategies and increased the speed of muscle force production compared to the other groups, suggesting that power/resistance training may be a fitness component to incorporate into body function and structure intervention if it relates to task goals (Table 9). (**Evidence Quality: II; Recommendation: Moderate**)

Supplemental Digital Content Table 9: Task-Oriented and Body Functions and Structures Interventions

Task-Oriented Interventions	Body Functions and Structures Interventions (used in the DCD literature)
• Motor Skills Training (MST) • Neuromotor Task Training (NTT) • Cognitive Orientation to daily Occupational Performance (CO-OP) • Motor Imagery (MI)	• Core Stability Training (CST) • Cardiorespiratory Training (CRT) • Functional Movement Power Training Program (FMPT)

Action Statement 10: RECOMMEND SUPPLEMENTAL ACTIVITIES TO AUGMENT THE FIRST-CHOICE INTERVENTION.

Descriptions of Supplemental Activities:

Soccer Training (Favor with trained coach)
Soccer training addresses skills that require coordination, speed, agility, endurance, and muscle power. Soccer training was used to determine the effects on motor performance using 50-minute sessions, 5 days a week for 10 weeks for children 9 to 10 years old with probable DCD.[75] Children who had soccer training significantly improved motor performance on pre/post total MABC-2 scores with a large effect size (d=1.34)[7] in favor of soccer training.[7,8,12] Soccer training programs included lower extremity exercises, soccer-specific technical skills, and practices with soccer matches. As a supplemental activity, PTs may recommend training with a soccer coach who has experience working with children with coordination difficulties. Children with DCD may experience frustration or decreased participation if the demands of recreational sports are greater than their motor, attentional, or cognitive skill levels.[110] (Evidence Quality: **I**; Recommendation Strength: **Strong**)

Taekwondo (TKD) (Favor with reservation about direct impact on function)
Taekwondo is a Korean Martial Arts known for its powerful kicks and jumps while focusing on balance and agility taught by a certified instructor. The effects of TKD was examined on standing balance, sensory organization, and leg strength in children with DCD, ages 6-12 years, over 12 weeks for 60-minute weekly sessions.[60,82] A home program was prescribed to reinforce skills taught during the TKD sessions. Children with DCD had a significant improvements on the SOT composite score[60,82] with a large effect size (0.80).[8] Single leg balance using the unilateral stance test (UST),[60,82] and knee strength measured with the Cybex Norm isokinetic dynamometer (Computer Sports Medicine Inc., Stoughton, MA, USA)[82] improved. No improvement was found in reactive balance with TKD using the Motor Control Test (MCT).[82] Taekwondo appears to improve components of physical fitness (balance and strength) that may benefit children with DCD. However, it is unknown if balance and strength improvements translate to functional skill or motor performance improvements.[8] (Evidence Quality: **II**; Recommendation Strength: **Moderate**)

Other Physical Activities in the Community (Favor)
Parents should also be informed that children with DCD may have lower levels of strength and conditioning, therefore activities to improve general fitness at home or in the community should be considered.[16,34] There is no clear evidence that PTs should recommend individual sports over team sports. However, there is evidence that children with DCD participate less in team sports and experience possible anxiety in larger groups.[63] Barriers to participation in sports include motor performance deficits and limited guidance on how children with DCD can be included in teams.[110] There may be some adapted community teams with skilled coaches who can work to assure positive experiences for children with DCD. Regardless, PTs should encourage families to consider individual or small group sports, such as swimming, hiking, golfing, climbing, or running (not all inclusive), where performance may be less likely to impact self-esteem. If progress is positive, team sports with a skilled coach may be considered. (Evidence Quality: **V**; Recommendation Strength: **Expert Opinion**)

General Guideline Implementation Strategies

There is a growing body of evidence on implementing research into practice. The following suggestions are provided as general strategies for clinicians to implement the action statements of this CPG but are not an exhaustive review. Many variables impact the successful translation of evidence into practice; clinicians will need to assess their own practice structures, cultures, and clinical skills to determine how to best implement the action statements as individuals and how to facilitate implementation by others. The GDG recommends that:

- Education about the 2020 DCD CPG should be included in physical therapy curricula.
- Continuing education programs should be provided to PTs on the 2020 DCD CPG.
- Physical therapists should distribute brochures developed by the APPT (https://pediatricapta.org/clinical-practice-guidelines/) that summarize the applicable key points of the 2020 DCD CPG to parents, physicians, and other health care providers.

Strategies for Individual Implementation

- Seek training to use the recommended standardized measures and/or intervention approaches.[116]
- Build relationships with referral sources to encourage early referral of children with delayed motor skill development or difficulty coordinating movement.
- Provide education to referral sources and community resources on DCD.
- Measure individual service outcomes of care (e.g., patient outcomes across the ICF domains, costs, parent/caregiver satisfaction).[117]

Strategies for Facilitating CPG Implementation in Other Clinicians

- Recognize that adoption of the recommendations by others may require time to learn about the 2020 DCD CPG content, develop a positive attitude toward adopting the action statements, compare what is already done with the recommended actions, trial selected practice changes to determine their efficacy, and establish routine integration of the tested changes.[117-120]
- Identify early adopting clinicians as opinion leaders to introduce the guideline via journal clubs or staff presentations.[117,118,120]
- Identify gaps in knowledge and skills following content presentations to determine staff needs to implement recommendations.[118,120]

- Use documentation templates to facilitate standardized collection and implementation of the recommended measures and actions.
- Institute quality assurance processes to monitor the routine collection of recommended data and implementation of recommendations and to identify barriers to complete collection.[117]
- Measure structural outcomes (e.g., dates of referral, equipment availability), process outcomes (e.g., use of tests and measures, breadth of plan of care), and service outcomes (e.g., effects of intervention across the ICF domains, costs, parent/caregiver satisfaction)[117] to describe service delivery patterns and publish results.

Summary of Research Recommendations

Action Statement 1: Complete a history and systems review.
- Clarify the precision of DCD screening procedures to establish more specific symptoms associated with DSM-5 Criteria C (Early Onset), and Criteria D (No Exclusionary Criteria).
- Clarify how medical, educational and participation history and screening factors influence the child's functional outcomes and physical therapy diagnosis and prognosis.

Action Statement 2: Make appropriate referrals.
- Data are needed about the number of children with coordination difficulties, at risk for or diagnosed with DCD who are examined by PTs and are referred for concerns about coexisting or exclusionary conditions, or confirmation of the DCD diagnosis. These data would establish the incidence of conditions discovered during the examination process and the effectiveness of referral patterns.

Action Statement 3: Complete participation outcome measures.
- Determine the most appropriate participation measure for children with coordination difficulties, at risk for DCD or a diagnosis of DCD. Longitudinal studies with participation measures would inform decisions about intervention and contribute to an understanding of participation restrictions over the lifespan.

Action Statement 4: Examine motor performance through movement analysis/observation.
- Identify movement quality characteristics and key activities to observe in infants and young children that predict DCD.
- Create a standard taxonomy of OMA characteristics for DCD.
- Verify OMA reliability and validity.

Action Statement 5: Examine activity limitations using questionnaires.
- Develop or clarify a comprehensive questionnaire to assess the breadth of activity limitations in children with DCD relevant to DSM-5 Criteria B (Participation and ADL Deficits).

Action Statement 6: Examine motor performance using standardized measures.
- Determine how scores obtained on the MABC-2 and BOT-2 correlate with activity and participation measures for children with DCD.
- A free motor skills checklist should be developed to standardize a core group of skills that could be used to assess children at risk for DCD.

Action Statement 7: Examine impairments of body functions and structures.
- Determine whether improving components of physical fitness increases physical activity participation for children with coordination difficulties, at risk for DCD or diagnosed with DCD; specifically, determining whether participation is positively impacted by strength, power, balance, or cardiorespiratory fitness/endurance improvements.

Action Statement 8: Provide task-oriented interventions combined with related body functions and structures interventions as the first-choice intervention.
- Determine whether improved motor performance and/or components of physical fitness affect participation in physical activities.

Action Statement 9: Use small group or individual sessions.
- Clarify the factors that influence decisions about group versus individual sessions, such as participants' motor impairment severity or diagnostic status of at risk for vs diagnosed DCD.
- Determine optimal combinations of group and/or individual-based sessions for improving motor performance in children with DCD.

Action Statement 10: Recommend supplemental activities to augment the first-choice interventions.
- Clarify which supplemental activities improve motor performance or increase participation in physical activities or recreation.

Action Statement 11: Provide education and home exercise programs to child/parents/caregivers or other significant adults.
- Determine the most effective training methods that PTs can provide for parents/caregivers and other significant adults to facilitate long-term training effects and general health.

Action Statement 12: Provide appropriate intervention dosages to improve motor performance.
- Develop standardized methods for documenting intervention dosages and clarify the optimal dosages for combined task-oriented and body functions and structures interventions that result in long-term motor performance improvements, accounting for motor impairment severity or diagnostic status of at risk for vs diagnosed DCD.

Action Statement 13: Provide collaborative communication about discharge recommendations for the episode of care.
- Develop long term follow up studies of children with DCD to describe factors and adaptations contributing to successful adult life.
- Determine whether adolescents or adults with DCD benefit from physical therapy interventions to address specific goals related to school, recreation or job-related performance.

Development of the Guideline

This CPG is the product of many people's work and support. At each phase of the update, the GDG has benefitted from the work and advice of clinicians, methodologists, and the families with whom we work. The following outlines the phases of this update and formally acknowledges the contributors in each phase.

Phase 1: Determine the aims of the CPG: topic selection and scope, authorship rules, identify advisory panel, identify expert content reviewers, identify GDG members
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Phase 2: Organizing the CPG development process: GDG responsibilities, establish a shared digital file system for organization, establish communication and project management procedures, prepare a draft document to organize methods and content
- Nicole Parker, PT, DPT, PCS
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Phase 3: Development of CPG guiding questions and scope based on the results of surveys and advisory panel discussion which included health care providers, teachers and a parent. Apply for CO IRB.
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Phase 4: Literature search and abstract review.
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Phase 5: Critically appraising the literature which included selection of critical appraisal tools, appraiser reliability training, critical appraisal ratings and recording results of appraisals.
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Phase 6: Development of action statements.
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Phase 7: Finalization of action statements with grades for recommendations based on level of evidence and literature summarization.
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Phase 8: Literature search and abstract review for additional systematic reviews.
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Phase 9: Addition of table and charts for clarity of the CPG Action Statements, completion of appendix items and completion of supplementary content
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Phase 10: First round review by content experts.
- Content Reviewers
- All first round reviewers declared an absence of conflicts of interest with the topic, process, and/or financial relationships.

Phase 11: External review of the revised CPG by the public and AGREE II ratings.
Following edits based on the first round review, a revised CPG draft was posted for public comment on the APTA APPT website. Notices were sent through the APPT electronic newsletter, posted on a physical and occupational therapy social media website, and sent individually to any clinicians who had inquired about the CPG during its update regarding the opportunity for comments. Comments were and may continue to be submitted to dcdguidelines@gmail.com.

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Supplemental Digital Content Evidence Tables 10 - 14

Supplemental Digital Content Evidence Table 10: Systematic Reviews of Test and Measures for Children with DCD

Author, Year	AMSTAR Score/ Quality Rating	Aim	Test and Measures Reviewed	Date Range & Studies	Quality of Evidence	Author conclusions
De Medeiros et al., 2017	7 / Medium	To identify the psychometric elements to an epistemological reflection through a systematic review of cross-cultural validation procedures of TGMD-2 batteries, MABC-2 and KTK.	•MABC-2 •TGMD-2 •KTK	Through October 2014 Qualitative: 10 studies	Did not assess or indicate the use of a quality measure.	Although some studies presented similar validation criteria, there is no consensus on the use of the recommended criteria for the cross-cultural validation of the instruments in question.
Griffiths et al., 2018	8 / High	Systematically evaluate the psychometric properties and clinical utility of gross motor assessment tools for children aged 2–12 years.	•Bayley-III •BOT-2 •MABC-2 •MAND •NSMDA •PDMS-2 •TGMD-2	Through July 2017 Qualitative: 30 studies, 7 manuals	Quality assessed using the Consensus-based Standards for the selection of health status Measurement Instruments checklist. It consists of three quality domains: validity, reliability and responsiveness.	The majority of gross motor assessments for children have good-excellent validity. Test–retest reliability is highest in the BOT-2, MABC-2, PDMS-2 and TGMD-2. The Bayley-III has the best predictive validity at 2 years of age for later motor outcome. None of the assessment tools demonstrate good evaluative validity.
Slater et al., 2010	5 / Medium	Systematically identify (1) performance-based outcome measures that assess gross motor skills of children with DCD, (2) literature reporting on the psychometrics of the identified measures in the DCD population and to evaluate the quality of these studies, and (3) the most robust outcome measure based on evaluation of the literature identified.	•BGMA •BOT-2 •MABC •MAND •PDMS-2 •TGMD-2 •ZNA	Through February 2008 Qualitative: 33 studies, 5 manuals	The studies identified all were at low to moderate risk of bias based on a modified critical appraisal tool from the NHMRC. This tool is referred to as the QCAT (designed by the authors).	MABC and TGMD-2 were found to score the highest on appraisal followed by the BOT-2. The authors recommend the MABC and the TGMD-2 to be considered for assessing the gross motor performance of children with DCD, but also recommend further studies be conducted to clarify the psychometric qualities of these tests. Specifically, the MABC needs further evidence of its validity, and the TGMD-2 requires psychometric testing with children with DCD to enable stronger justification for use in this population.
van der Linde et al., 2015	6 / Medium	Systematically review those instruments that might provide standardized and objective assessment of children's capacity in ADL.	•BOT-2 •Do-Eat •MABC-2 •SchoolAMPS •TAMP •TGMD-2 •WeeFIM	Through November 2011 Qualitative: 66 studies	Did not assess or indicate the use of a quality measure.	Current instruments do not provide comprehensive and ecologically valid assessment of capacity in ADL as required for children with DCD.

Abbreviations: AMSTAR, a measurement tool for the assessment of multiple systematic reviews; Bayley III, Bayley Scale of Infant and Toddler Development-III; BGMA, Basic Gross Motor Assessment; BOT-2, Bruininks-Oseretsky Test of Motor Performance-2; DCD, Developmental Coordination Disorder; KTK, körperkoordinationstest für Kinder; MABC, Movement Assessment Battery for Children; MABC-2, Movement Assessment Battery for Children–Second Edition; MAND, McCarron Assessment of Neuromuscular Development; NHMRC, National Health and Medical Research Council; NSMDA, Neurological Sensory Motor Developmental Assessment; QCAT, Quality Critical Appraisal Tool; SchoolAMPS, the school-Assessment of Motor and Process Skills; TAMP, Tufts Assessment of Motor Performance;TGMD-2, Test of Gross Motor Development; WeeFIM, Functional Independence Measure for Children; ZNA, Zurich Neuromotor Assessment

Supplemental Digital Content Evidence Table 11: Systematic Reviews/Meta-analysis of Interventions for Children with DCD

Author, Year	AMSTAR Score/ Quality Rating	Aim	Intervention of Interest and Outcome Measures	Date Range & Studies (participants)	Quality of Evidence	Relative Effects	Author conclusions
Cavalcante Neto et al., 2018	9/ High	Synthesis of evidence on the effectiveness of AVG interventions for motor performance improvement in children with DCD.	Intervention: AVG Outcomes: Measures for motor performance	January 2006 to 30 November 2017 Qualitative: 12 RCT/ CCT	Methodological quality was determined using PEDro Scale (only 5 out of 12 were considered low quality, <5). Quality of evidence was assessed by the GRADE (66% showed positive effects).	No meta-analysis secondary to the heterogeneity among the studies	The GRADE analysis showed a low level of evidence in favor of the AVG approach as an intervention for motor performance improvement in children with DCD.
Miyahara et al., 2017	11 / High	To assess the effectiveness of task-oriented interventions on movement performance, psychosocial functions, activity, and participation for children with DCD and to examine differential intervention effects as a factor of age, sex, severity of DCD, intervention intensity, and type of intervention.	Intervention: Task-oriented Intervention (Aquatics, CO-OP, MI, MST, Soccer, Table Tennis) Outcomes: Multiple measures for Motor performance. Only studies reporting on results from the MABC were part of the meta-analysis	Through April 2017 Qualitative: 649 (15) Quantitative: 169 (6)	Low quality overall using the GRADE approach and Cochrane's Risk of bias tool. Downgrading secondary to randomization and blinding.	Test for overall effect*: z=3.17 (p=0.002), CI = -5.88 to -1.39*	Task-oriented interventions may be useful for children with DCD in improving performance on movement tests. We cannot be sure about benefits in other areas. Higher-quality research is needed to investigate and establish the effect of task-oriented intervention for children with DCD.
Norris et al., 2016	10 / High	To assess the quality of evidence for the effects of school AVG use on physical activity and health outcomes.	Interventions: AVG Outcomes: 11 studies - physical activity (accelerometry, pedometer and HR monitoring), 6 studies - physical activity and health (BMI and body composition), 5 studies - motor outcomes only (BOT-2, MABC, TGMD and balance)	Through June 2015 Qualitative: 22 studies	Studies quality was low (weak) based on the Effective Public Health Practice Project tool (National Collaborating Center for Methods and Tools, 2008). 7 studies scored moderate and 15 scored weak.	No meta-analysis	There is currently insufficient evidence to recommend AVGs as efficacious health interventions within schools. Higher quality AVG research utilizing randomized controlled trial designs, larger sample sizes, and validated activity measurements beyond the school day is needed.

Supplemental Digital Content Evidence Table 11: Systematic Reviews/Meta-analysis of Interventions for Children with DCD

Preston et al., 2016	11 / High	To identify effective motor training interventions for children with developmental coordination disorder from research graded as high quality (using objective criteria) for the purpose of informing evidence-based clinical practice.	Interventions: Motor-Based Interventions: (AVG, Aquatics, CST, MI, MST, NTT, Soccer, Table Tennis, Task-oriented Interventions, TKD) Outcomes: 7 studies - activity (MABC-2), 1 study - activity (BOT-2), 1 study - body function (SOT)	January 2000 to March 2016 Quantitative: 311 (9)	High quality based on a score of 7 or higher on the PEDro scale.	No meta-analysis Forrest plot was used to give the effect size and CI of the 9 studies individually as part of the qualitative analysis.	Large effect sizes associated with 95% confidence intervals suggest that 'Neuromotor Task Training', 'Task-oriented Motor Training' and 'Motor Imagery + Task Practice Training' are the most effective reported interventions for improving motor skills in children with developmental coordination disorder. Wii, CST, self-concept training, Tai Kwon Do, table tennis and aquatic therapy are not supported by the available evidence.
Smits-Engelsman et al., 2018	10 / High	To review systematically any study reporting new data on the motor outcomes of intervention for children or adults with DCD	Interventions: Motor-Based Intervention (AVG, CRT, CO-OP, CST, MI, MST, NTT, Soccer, Visual Training, Task-oriented Interventions, TKD) Outcomes: activity level (MABC-1 or 2, BOT-1 or 2 or agility and functional fitness tasks), body function and participation.	January 2012 to February 2017 Qualitative: 30 studies Quantitative: 19 studies	Level of evidence ranged from high quality RCTs (1++) to Clinical Trials (2-) with a high risk for bias based on a revised grading system adapted from Research System Agency for Health Care Policy.	A large effect size of *d = 1.06* (Cohen's d) across 25 intervention studies with variability listed below. 11 studies: large (> 0.80) 8 studies: moderate (> 0.50) 5 studies: small or negligible (< 0.50) CI not reported.	Results showed that activity-oriented and body function interventions can have a positive effect on motor function and skills. However, given the varied methodological quality and the large confidence intervals of some studies, the results should be interpreted with caution.
Smits-Engelsman et al., 2013	8 / High	To review systematically evidence about the efficacy of motor interventions for children with developmental coordination disorder (DCD), and to quantify treatment effects using meta-analysis.	Interventions: Task-Oriented Intervention, traditional physical and occupational therapies, process-oriented therapies, and chemical supplements. Outcomes: multiple measures for motor performance, strength, balance, handwriting, and self-perception/ satisfaction.	1995 and 2011 Qualitative: 26 studies Quantitative: 20 studies	Quality of these studies (mean score was 6.0 (4.0 -10) based on the guidelines of the Oxford Centre for Evidence-based Medicine -Levels of Evidence.	The mean effect size across all treatment types was moderate *(d=0.56)* (Cohen's d). Effect size for each type of intervention: Task-oriented = strong *(d=0.89),* Physical and Occupational therapies = strong *(d=83)* process-oriented therapy = weak *(d=0.12)* CI not reported.	Strong evidence for task-oriented approaches, Physical and Occupational therapies to improve motor outcomes. Process oriented interventions had conflicting evidence on the effects of motor performance.

Supplemental Digital Content Evidence Table 11: Systematic Reviews/Meta-analysis of Interventions for Children with DCD

Yu et al., 2018	10 / High	To determine the characteristics and effectiveness of motor skill interventions in children with DCD and to identify potential moderators of training effects using meta-analysis.	Interventions: Motor Skills Intervention (Aquatics, AVG, CRT, CO-OP, CST, Horseback Riding, MI, MST, NTT, Soccer, Trampoline, Visual Training, Task-oriented Interventions) Outcomes: multiple measures for motor performance and cognitive, emotional, and other psychological factors.	1995 to August 2017 Qualitative: 66 studies Quantitative: 18 studies	Risk of bias assessed using a short scale of 6 criteria established by Cochrane Collaboration.	Effect size was moderate for motor performance (*Hedges g = .63; 95% CI [31, .94]; P<.001)* and cognitive, emotional, and other psychological factors *(Hedges g= 0.65; 95% CI [0.25, 1.04]; P=.001).* Effect size for process-oriented interventions (Hedge's g = 0.20, 95% CI [-0.45, 0.84]; P = 0.549). Task-oriented interventions (Hedge's g = 0.62; 95% CI [-0.05, -1.30]; P = 0.071. Task-oriented interventions combined with process-oriented (Hedge's g = 0.83; 95% CI [0.40, 1.27]; P < 0.001)	Motor skill interventions are effective in improving motor competence and performance on cognitive, emotional, and other psychological aspects in children with DCD in the short term. These effects are more robust in interventions using a large training dose and a practicing schedule of high frequency.

Abbreviations: AMSTAR, a measurement tool for the assessment of multiple systematic reviews AVG, active video gaming; BMI, body mass index; BOT-2, Bruininks-Oseretsky Test of Motor Performance-2; CCT, controlled clinical trial; CI, confidence interval; CO-OP, Cognitive Orientation to daily Occupational Performance; CRT, cardiorespiratory training; CST, core stability training; DCD, Developmental Coordination Disorder; GRADE, grading of recommendations assessment, development and Evaluation, HR, heart rate; MABC, Movement Assessment Battery for Children; MABC-2, Movement Assessment Battery for Children 2nd Edition; MI, motor imagery; MST, motor skills training; NTT, Neuromotor Task Training; OT, occupational therapist; PT, physical therapist; RCT, random controlled trial; SOT, Sensory Organization Test; TGMD, Test of Gross Motor Development; TKD, taekwondo

Supplemental Digital Content Evidence Table 12: Task-Oriented Intervention Studies for Children with DCD

Author & Year	Study Design / Level of Evidence / CAT-EI Score	DSM and Criteria	Experimental / Comparison / Age or Participants	Intervention intensity, frequency, duration	Intervention	Outcome Measures	Author Conclusions
Au et al., 2014	RCT, Level I 7/12 = 58%, Level I	DSM-IV Criteria A: MABC ≤ 15th or BOT-2 < 1.5 SD on two or more subtests Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Core stability training, children with DCD, n=11 (3 girls, 8 boys) Comparison: Task-oriented training, children with DCD, n=11 (4 girls, 7 boys) 6 to 12 yo, Hong Kong, China	60 min. session 1 time a week 8 weeks Daily HEP	Task-oriented training group focused on training using functional positions that included standing (body stability), walking, running, jumping, hopping, skipping and galloping (body transport). Intervention material: soccer balls, obstacles, goal posts. CST group used a physio ball as the treatment tool in supine, prone, sitting and standing. Both groups instructed to perform a daily HEP.	Activity Participation: •BOT 2 SF •Parent survey Body Function: •SOT	Core stability exercises are as effective as task-oriented training to improve motor proficiency in children with DCD. Task-oriented training yielded better results for dynamic balance.
Bonney et al., 2017	CCT, Level II 8/12 = 67%, Level II	DSM-5 Criteria A: MABC-2 ≤ 16th Criteria B: Self report Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented, girls with suspected DCD, n=22 (22 girls) Comparison: AVG (Wii FIT), girls with suspected DCD, n=21 (21 girls) 13 to 16 yo, South Africa	45 min. session 1 time a week 14 weeks	AVG group was supervised using balance boards with the Wii Fit console while playing a maximum of 8 games per session. Task-oriented group participated in warm-up, motor skill intervention and game play.	Activity Participation: •MABC-2 •BOT-2 •CSAPPA Body Function: •Dynamometer for knee and ankle •20 m shuttle run	Activity based interventions (task-oriented and Wii Fit) may yield positive benefits across ICF levels for female adolescents with DCD. These two interventions seem to provide similar short-term benefits and can be implemented to enhance functional performance, participation and generalized self-efficacy.
Caçola et al., 2016	Pilot study, Level III 2/12 = 17%, Level II	DSM-5 Criteria A: MABC-2 < 9th Criteria B: DCDQ'07 Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented (MST) in a large group, children with suspected DCD, n=11 (1 girl, 10 boys) Comparison: Goal oriented approach with smaller groups, children with suspected DCD, n=13 (4 girls, 9 boys) 7 to 12 yo, Texas , USA	60 min. session 1 time a week 10 weeks	Large group, task-oriented activities focusing on collaboration and cooperation among children Small group, divided into 3 smaller groups, activities address motor goals chosen by the children Both groups started with a warm-up and followed by a series of activities aimed at children's goals.	Activity Participation: •MABC-2 •CSAPPA •CAPE •PAC •DCDQ'07 •SDQ Body Function: •SCAS	Both group-based task-oriented training and goal-oriented training were effective in improving balance and overall motor skills in children with DCD.

Supplemental Digital Content Evidence Table 12: Task-Oriented Intervention Studies for Children with DCD

Farhat et al., 2016	CCT, Level II 6/12 = 50%, Level II	DSM-5 Criteria A: MABC ≤ 15th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented (MST), children with DCD, n=14 (14 boys) Comparison: No intervention, children with DCD, n=13 (13 boys) Comparison: No intervention, TD children, n =14 (14 boys) 6 to 10 yo, region of Tunisia	60min. session 3 times a week 12 weeks	Children were trained in fundamental gross motor skills (hopping, jumping, throwing and catching). It consisted of 10 min warm-up, 35–45 min fitness and agility training and 5 min recovery time. Two sport teachers were responsible for the intervention.	Activity Participation: •MABC •MAT •HQ & HS •Enjoyment Scale Body Function: •THD •5JT •MD •BS	Group-based motor skills training is effective in improving gross and fine motor skills in children with DCD, leading to improved motor coordination and handwriting. Improvements in physical ability (power, explosive strength, agility) with training were also observed.
Farhat et al., 2015	CCT, Level II 8/12 = 67%, Level II	DSM-IV Criteria A: MABC ≤ 15th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented (MST), children with DCD, n=14 (14 boys) Comparison: No intervention, children with DCD, n=13 (13 boys) Comparison: No intervention, TD children, n =14 (14 boys) 7 to 9 yo, region of Tunisia	60 min. session 3 times a week 8 weeks	Children were trained in fundamental gross motor skills (hopping, jumping, throwing and catching). It consisted of 10 min warm-up, 35–45 min fitness and agility training and 5 min recovery time. Two sport teachers were responsible for the intervention.	Activity Participation: •MABC •6MWT •PCERT Body Function: •CPET •PFT	8-week training program improved cardiorespiratory fitness and perceived exertion during activity for children with DCD.
Ferguson et al., 2013	CCT, Level II, 8/12 = 67%, Level II	DSM-IV Criteria A: MABC-2 ≤15th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: NTT, children with DCD, n=27 (12 girls, 15 boys) Comparison: AVG (Wii Fit), children with DCD, n=19 (10 girls, 9 boys) 6–10 years, South Africa	45-60 min. session 2 times a week 9 weeks	NTT group: Workstations were set-up to practice components of games under the guidance therapists who manipulated the environment and or task as needed. Balls, buckets, cups, sticks, planks and bricks were used. Therapists used guided discovery to facilitate implicit learning and provided positive feedback. Children worked in groups of 7. AVG: Wii Fit console with balance boards were used in a single room where children simultaneously played various games under supervision while at school.	Activity Participation: •MABC-2 •FSM Body Function: •HHD •MPST •20 m shuttle run	The NTT approach is an effective approach to address motor coordination, functional strength and cardiorespiratory fitness in children with DCD when used in a group format. The Wii training intervention did not result in significant improvement in motor proficiency.

Supplemental Digital Content Evidence Table 12: Task-Oriented Intervention Studies for Children with DCD

Fong et al., 2016 (FMPT + FMT)	RCT, Level I 11/12 = 92%, Level II	DSM-IV Criteria A: MABC < 5th, BOT-2 ≤ 42 Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: FMPT, children with DCD, n=42 (14 girls, 28 boys) Comparison: FMT, children with DCD, n=47 (14 girls, 33 boys) Comparison: No intervention, children with DCD, n=41 (13 girls, 28 boys) 6 to 10 yo, Hong Kong, China	60 min. session 2 times a week 12 weeks	The FMT group received task-specific training (balance exercises modified from the MABC) concurrent with electromyographic biofeedback. The FMPT group received power/resistance training (focused on postural muscle strength and contraction speed of the lower extremity) after the FMT protocol.	Body Function: •SOT •Lafayette Manual Muscle Test System	FMPT appears to be effective as a stand-alone intervention designed to improve balance strategies, postural stability, and leg muscle performance in children with DCD.
Fong et al., 2016 (FMT only)	RCT, Level II 10/12 = 83%, Level II	DSM-IV Criteria A: MABC < 5th, BOT-2 ≤ 42 Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: FMT, children with DCD, n=): 47 (14 girls, 33 boys) Comparison: No intervention, children with DCD, n=41 (13 girls, 28 boys) 6 to 10 yo, Hong Kong, China	90 min. session 2 times a week 12 weeks	The FMT group received task-specific training (balance exercises modified from the MABC) concurrent with electromyographic biofeedback.	Activity Participation: •MABC Body Function: •SOT •UST	The results of both the MABC and the UST indicated that the balance performance of the FMT group was significantly better than that of the control group at 3 and 6 months (all $P < 0.05$). Task-specific balance training was found to marginally improve the somatosensory function and somewhat improve the balance performance of children with DCD.
Hammond et al., 2013	RCT, Level II 6/12 = 50%, Level III	No report Criteria A: No specific measure Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: AVG(Wii Fit), children with DCD/motor difficulties, n=10 Comparison: Jump Ahead Program, children with DCD/motor difficulties, n=8	10 min. session 3x a week 4 weeks	2 phases of intervention (4 weeks each). Group A received 10 min of supervised play on Wii Fit at school, which focused on balance and coordination. Group B participated in the school-run Jump Ahead intervention. Phase 2, the groups participated in the alternative intervention (4 weeks).	Activity Participation: •BOT 2 •CSQ •SDQ	This study provides preliminary evidence to support the use of the Wii Fit within therapeutic programs for children with movement difficulties.
Hillier et al., 2010	CCT, Level II 10/12 = 83%, Level II	DSM-IV Criteria A: MABC < 15th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented (aquatics), children with DCD, n=6 (1 girl, 4 boys) Comparison: No intervention/wait list, children with DCD, n=6 (1 girl, 4 boys) 7-10 yo, Mid-Sussex, UK	30 min. session 1 time a week 6 weeks	Aquatic therapy consisted of practicing movement strategies and specific tasks that could potentially improve skill sets and postural control.	Activity Participation: •MABC •PSPCSA	Aquatic therapy is a feasible intervention for children with DCD and may be effective in improving their gross motor skills.

Supplemental Digital Content Evidence Table 12: Task-Oriented Intervention Studies for Children with DCD

Hung et al., 2010	RCT, Level II 8/12 = 67%, Level II	DSM-IV Criteria A: MABC ≤ 15th BOT-2 ≤ 42 Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented (group-based motor skills training), children with DCD, n =12 Comparison: Task-oriented (individual based motor skills training), children with DCD, n =11 6 to 10 yo, China	45 min. session 1 time a week 8 weeks	Children performed variety of functional tasks and exercises address common motor difficulties such as agility, balance, core stability, and movement coordination. The individual ratio was 1:1 and group ration was 4-6:1.	Activity Participation: •MABC •HEP logbook •Parent Satisfaction Questionnaire	Group-based training produced similar gains in motor performance to individual-based training. Group- based training may be the preferred treatment option due to the associated cost savings.
Hyland et al., 2011	Case Control, Level III 2/12 = 17%, Level III	DSM-IV Criteria A: MABC < 15th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: CO-OP, children with DCD, n =10 Comparison: Impairment based intervention, children with DCD, n =8 7 to 12 yo, Canada	50 min. session 1 time a week 10 weeks	Videotaped recordings were analyzed from two CO-OP studies (Miller 2001; Corcoran, Cameron, Tong 2005)	Activity Participation: •DPA	The study illustrates that children with DCD are able to generate DPAs indicating that they recognize that their motor performance is not competent. DPA is ‘‘an iterative process, where the child verbally identifies that something has gone wrong with the performance and identifies the cause of the performance difficulties being experienced.’’
Jokić et al., 2013	CCT, Level III 4/12 = 33%, Level III	DSM-IV Criteria A: MABC ≤ 5th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: CO-OP, children with DCD, n =5 (5 boys) Experimental: CO-OP, children with DCD and cooccurring conditions, n =5 (1 girl, 4 boys) Comparison: No control group 7 to 9 yo, Canada	30 min. session 2 times a week 5 weeks	Observational study of children performing tasks using CO-OP	Activity Participation: •Performance Quality Rating Scale •Observational Coding Scheme	This study suggests that a CO-OP approach to intervention will assist children with DCD to successfully find solutions to motor performance problems and improved self-regulatory performance.
Kane et al., 2009	Case Reports, Level IV 3/12 = 25%, Level IV	DMS IV Criteria A: BOTMP-SF Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented (motor skills) with core stability exercises, children with DCD, n=3 (2 girls, 1 boys) Comparison: No control group 9 to 11 yo, Canada	55 min. session 2 times a week 6 weeks Weekly HEP	20-minute aerobic warm-up, 15 minutes of core stability exercises, and 20 minutes of task-specific intervention and sport skills training based on the child’s chosen goals. A written HEP was given to be performed each week.	Activity Participation: •BOTMP-SF •CSAPPA •Self-chosen goal rating Body Function: •Core stability measure	The results of this pilot work suggest that further exploration of the developmental aspects of core stability, its assessment, and the implementation of training in this population is warranted.

Supplemental Digital Content Evidence Table 12: Task-Oriented Intervention Studies for Children with DCD

Thornton et al., 2016	RCT, Level II 6/12 = 50%, Level III	DSM-IV Criteria A: MABC-2 Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: CO-OP, children with DCD, n = 10 (10 boys) Comparison: No intervention, children with DCD, n = 10 (10 boys) 8 to 10 yo, Australia	60 min. session 1 time a week 10 weeks Daily HEP x 15 min.	Individual CO-OP session was focused on the global problem-solving strategy, described as the Goal-Plan-Do-Check method, to create strategies to improve the child's functional performance and goal achievement. The group program was developed to address at least 2–3 goals for each child and was themed as a Police Detective Club.	Activity Participation: •MABC-2 •HST •COPM •GAS Body Function: •3D motion analysis •Flex-sensor glove	CO-OP as an intervention for children with DCD showed some improvement in performance across the impairment (decreased motor overflow), participation (improved ratings of perceived performance and satisfaction) and activity levels (handwriting) of the ICF. No was no significant change in motor proficiency based on the results of the MABC-2.
Tsai et al., 2014	CCT, Level II 6/12 = 50%, Level III	DSM-IV Criteria A: MABC < 5th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Endurance exercise training, children with DCD, n=20 (7 girls, 13 boys) Comparison: No training, children with DCD, n=20 (8 girls, 12 boys) Comparison: Endurance exercise training, TD children, n=20 (8 girls, 12 boys) 11 to 12 yo, Taiwan	50 min. session 3 times a week 16 weeks	The DCD-training group participated in an endurance training program led by an adapted physical education teacher while at school. The endurance training program consisted of interval training, long-distance running session, and one session with another aerobic activity (e.g., cycling, step aerobics, or rope jumping).	Activity Participation: •MABC-2 •VWMP Body Function: •PACER •ERP Indices	These findings suggest that increased cardiorespiratory fitness could effectively improve the performance of the VSWM task in children with DCD, by enabling the allocation of greater working memory resources related to encoding and retrieval.
Zwicker et al., 2015	Case Series, Level IV 6/12 = 50%, Level III	DSM-IV Criteria A: MABC-2 ≤ 5th or ≤ 5th on one subtest of MABC-2 Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: CO-OP, children with DCD, n=11 (2 girls, 9 boys) Comparison: No control group 7 to 12 yo, Canada	90 min. session 4 session total 2 weeks	The DCD summer camp staff (2:1 child to staff) consisted of Occupational Therapy, Physical Therapy or Rehabilitation Assistant students who received training in the CO-OP approach. Camp participants engaged in a variety of group-based activities including 4 individual session to work on their chosen goal using the CO-OP approach.	Activity Participation: •COPM •PEGS •CSAPPA •CAPE	The intensive, group-based summer camp using CO-OP as intervention significantly improved performance and satisfaction ratings of child-chosen goals and confirms that task-specific, cognitive interventions are effective in improving subjective measures of functional motor goals for children with DCD. No measures were completed for motor performance.

Abbreviations; AVG, active video gaming; BOT-2/SF, Bruininks-Oseretsky Test of Motor Performance-2; BS, ball skills; CAPE, Children's Assessment of Participation and Enjoyment; CAT-EI, Critical Appraisal Tool for Experimental Intervention Studies; CCT, controlled clinical trial; CO-OP, Cognitive Orientation to daily Occupational Performance; COPM, Canadian Occupational Performance Measure; CPET, cardiopulmonary exercise test; CRT, cardiorespiratory training; CSAPPA, Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity Scale; CSQ, Coordination Skills Questionnaire; CST, core stability training; DCD, Developmental Coordination Disorder; DCDQ'07, Revised Developmental Coordination Disorder Questionnaire 2007; DPA, dynamic performance analysis; DSM-IV, Diagnostic Statistical Manual for Mental Disorders, version IV; DSM-5, Diagnostic Statistical Manual for Mental Disorders, version 5; ERP, event-related potentials; FMT, functional movement training; FMPT, functional movement power training; FSM, functional strength measure; GAS, Goal Attainment Scale; HEP, home exercise program; HHD, hand held dynamometry; HS, Handwriting Speed; HQ, Handwriting Quality; HST, Handwriting Speed Test; ICF, International Classification of Functioning, Disability, and Health; MABC, Movement Assessment Battery for Children; MABC-2, Movement Assessment Battery for Children – Second Edition; MAT, Modified Agility test; MD, manual dexterity; MPST, muscle power sprint test; MST, Motor Skill Training; NTT, Neuromotor Task Training; PAC, Preferences for Activities of Children; PACER, Progressive Aerobic Cardiovascular Endurance Run; PCERT, Pictorial Children's Effort Rating Table; PEGS, Perceived Efficacy and Goal Setting; PFT, pulmonary function test; PSPCSA, Pictorial Scale of Perceived Competence and Social Acceptance; PT, physical therapist; RCT, randomized controlled trial; SCAS, Spence's Child Anxiety Scale; SDQ, Strengths and Difficulties Questionnaire; SOT, Sensory Organization Test; TD, typically developing; UST, unilateral stance test; VSWM, visuospatial working memory; VWMP, Visuospatial Working Memory Paradigm; yo, years old; 3D, 3 dimensional; 5JT, 5 jump test; 6 MWT, six minute walk test.

Supplemental Digital Content Evidence Table 13: Supplemental Intervention Studies for Children with DCD

AVG							
Author & Year	**Study Design / Level of Evidence / CAT-EI Score**	**DSM and Criteria**	**Experimental / Comparison / Age or Participants**	**Intervention intensity, frequency, duration**	**Intervention**	**Outcome Measures**	**Author Conclusions**
Bonney et al., 2017	CCT, Level II 8/12 = 67%, Level II	DSM-5 Criteria A: MABC-2 ≤ 16th Criteria B: Self report Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Task-oriented, girls with suspected DCD, n=22 (22 girls) Comparison: AVG (Wii FIT), girls with suspected DCD, n=21 (21 girls) 13 to 16 yo, South Africa	45 min. session 1 time a week 14 weeks	AVG group was supervised using balance boards with the Wii Fit console while playing a maximum of 8 games per session. Task-oriented group participated in warm-up, motor skill intervention and game play.	Activity Participation: •MABC-2 •BOT-2 •CSAPPA Body Function: •Dynamometer for knee and ankle •20 m shuttle run	Activity based interventions (task-oriented and Wii Fit) may yield positive benefits across ICF levels for female adolescents with DCD. These two interventions seem to provide similar short-term benefits and can be implemented to enhance functional performance, participation and generalized self-efficacy.
Ferguson et al., 2013	CCT, Level II, 8/12 = 67%, Level II	DSM-IV Criteria A: MABC-2 ≤15th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: NTT, children with DCD, n=27 (12 girls, 15 boys) Comparison: AVG (Wii Fit), children with DCD, n=19 (10 girls, 9 boys) 6–10 years, South Africa	45-60 min. session 2 times a week 9 weeks	NTT group: Workstations were set-up to practice components of games under the guidance therapists who manipulated the environment and or task as needed. Balls, buckets, cups, sticks, planks and bricks were used. Therapists used guided discovery to facilitate implicit learning and provided positive feedback. Children worked in groups of 7. AVG: Wii Fit console with balance boards were used in a single room where children simultaneously played various games under supervision while at school.	Activity Participation: •MABC-2 •FSM Body Function: •HHD •MPST •20 m shuttle run	The NTT approach is an effective approach to address motor coordination, functional strength and cardiorespiratory fitness in children with DCD when used in a group format. The Wii training intervention did not result in significant improvement in motor proficiency.
Hammond et al., 2013	RCT, Level II 6/12 = 50%, Level III	No report Criteria A: No specific measure Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: AVG(Wii Fit), children with DCD/motor difficulties, n=10 Comparison: Jump Ahead Program, children with	10 min. session 3x a week 4 weeks	2 phases of intervention (4 weeks each). Group A received 10 min of supervised play on Wii Fit at school, which focused on balance and coordination. Group B participated in the school-run Jump Ahead intervention. Phase 2, the	Activity Participation: •BOT 2 •CSQ •SDQ	This study provides preliminary evidence to support the use of the Wii Fit within therapeutic programs for children with movement difficulties

Supplemental Digital Content Evidence Table 13: Supplemental Intervention Studies for Children with DCD

			DCD/motor difficulties, n=8		groups participated in the alternative intervention (4 weeks).		
Howie et al., 2016	RCT, Level II 8/12 = 67%, Level II	DSM-IV Criteria A: MABC-2 ≤ 16th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: AVG, children diagnosed or suspected with DCD, n=21 (11 girls, 10 boys) Comparison: Same group, no AVG x 16 weeks 10 to 12 yo, Perth, AUS	20 min. session 4 to 5 times a week 16 weeks	Children were instructed to play games with the provided Xbox 360 and PlayStation 3 without supervision while at home. They were able to choose between a variety of games with components of gross and fine motor skills. During the control period they were able to choose any type of AVG.	Activity Participation: •Accelerometer •Self-Reported Activity Log	No significant changes in physical activity as measured by accelerometer, and unexpected finding was that children participating in AVG spent less time playing outside.
Jelsma et al., 2014	CCT, Level II 8/12 = 67%, Level II	No report Criteria A: MABC-2 ≤16th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: AVG (Wii Fit protocol: 6 weeks of intervention), children with DCD, n= 14 Experimental: AVG (Wii Fit protocol: 6 weeks no intervention, then 6 weeks intervention), children with DCD, n= 14 Comparison: No intervention, TD children, n=20 6-12 yo, Dutch and South Africa	30 min. session 3 times a week 6 weeks	Supervision of children playing Wii Fit games by a trainer. Played each game 2x, then switch (variability).	Activity Participation: •MABC-2 •BOT-2 •Enjoyment Scale Body Function: •Wii Fit Slalom Ski Test	Training with the Wii Fit consistently improved motor balance items of the MABC-2 and BOT-2. The improvements after the intervention were significantly larger or almost significantly larger in motor test results, than changes due to normal development or test–retest effect.
Smits-Engelsman et al., 2015	CCT, Level II 4/12 = 33%, Level III	DSM-5 Criteria A: MABC-2 < 5th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: AVG (Wii Fit), children with DCD, n=17 Comparison: AVG (Wii Fit), TD children, n=17 6-10 yo, South Africa	20min. session 2 times a week 5 weeks	Ski Slalom Wii Game played until 100 trials were completed over a period of time.	Activity Participation: •MABC-2 •BOT-2 •Enjoyment Rating Scale Body Function: •Wii Fit Slalom Scores	Our findings suggest that the use of active video games may have the potential to be a valuable additional tool in intervention. Children with DCD improved in all balance tasks.

Supplemental Digital Content Evidence Table 13: Supplemental Intervention Studies for Children with DCD

Straker et al., 2015	RCT, Level II 6/12 = 50%, Level III	DSM-5 Criteria A: MABC-2 ≤16th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: AVG x 16 weeks then no AVG, children diagnosed or suspected DCD, n=10 (10 boys) Comparison: No active AVG for 16 weeks then AVG, children diagnosed or suspected DCD, n=11 (11 boys) 9 to 12 yo, Australia & New Zealand	20 min. session 4 to 7 times a week 16 weeks	AVG consisted of playing video games using the Sony PlayStation at home.	Activity Participation: •MABC-2 •DCDQ'07 •Self-Report on activity Body Function: •3D motion analysis of single leg stance and finger to nose •Accelerometer	There was no significant difference in motor skills in children with DCD following a 16-week AVG intervention and a 16-week period of no intervention. However, the children perceived enhanced motor skills at the completion of the AVG condition in comparison to the NAG condition. Therefore, home-based AVG might have positive implications for children with DCD, despite no immediate change in motor coordination.
Soccer Training							
Author & Year	**Study Design / Level of Evidence / CAT-EI Score**	**DSM and Criteria**	**Experimental / Comparison / Age or Participants**	**Intervention intensity, frequency, duration**	**Intervention**	**Outcome Measures**	**Author Conclusions**
Tsai et al., 2012	RCT, Level II 5/12 = 42%, Level II	DSM-IV Criteria A: MABC < 5th Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: Soccer training, children with DCD, n =16 (7 girls, 9 boys) Comparison: Non-training group, children with DCD, n=14 (5 girls, 9 boys) Comparison: Non-training group, TD children, n=22 (10 girls, 12 boys) 9 to 10 yo, Taiwan	50 min. session 5 times a week 10 weeks	A trained soccer coach in the school setting provided face-to-face group session using soccer balls, obstacles and goal posts. Intervention included a warm-up, soccer training, playing a game and a cool down. Emphasis first on general skills and then on task-specific skills.	Activity Participation: •MABC Body Function: •ERP Indices	The data suggest that soccer training resulted in significant improvements in ERP and task performance indices for the children with DCD.
TKD Training							
Author & Year	**Study Design / Level of Evidence / CAT-EI Score**	**DSM and Criteria**	**Experimental / Comparison / Age or Participants**	**Intervention intensity, frequency, duration**	**Intervention**	**Outcome Measures**	**Author Conclusions**
Fong et al., 2013	RCT, Level II	DSM-IV Criteria A: Clinical dx. of DCD Criteria B: Did not specify	Experimental: TKD, children with DCD,	60 min. session 1 time a week 6 weeks	A TKD training protocol was modified by an experienced physical therapist and a skilled	Body Function: •UST	The results show that children with DCD who undergo a 3-month program of intensive TKD training experience

Supplemental Digital Content Evidence Table 13: Supplemental Intervention Studies for Children with DCD

	11/12 = 92%, Level II	Criteria C: Did not specify Criteria D: Reported on criteria	n =21 (4 girls, 17 boys) Comparison: No intervention, children with DCD, n=23 (5 girls, 18 boys) Comparison: No interventions, TD children, n=18 (4 girls, 14 boys) 6 to 12 yo, Hong Kong, China	Daily HEP	TKD practitioner. The session was conducted by a World Taekwondo Federation 4th dan black belt qualified as a chief instructor and a 2nd dan black belt qualified as an assistant instructor. Children were also given a HEP to practice skills being taught.	•MCT •Isokinetic quadriceps and hamstrings	improvements in isokinetic knee muscle strength at 1808/s and static single-leg standing balance control, but do not benefit from improved reactive balance control.
Fong et al., 2012	RCT, Level II 11/12 = 92%, Level II	DSM-IV Criteria A: Clinical dx. of DCD Criteria B: Did not specify Criteria C: Did not specify Criteria D: Reported on criteria	Experimental: TKD, children with DCD, n =21 (4 girls, 17 boys) Comparison: No intervention, children with DCD, n=23 (5 girls, 18 boys) Comparison: No interventions, TD children, n=18 (4 girls, 14 boys) 6 to 9 yo, Hong Kong, China	60 min. session 1 time a week 12 weeks Daily HEP	A TKD training protocol was modified by an experienced physical therapist and a skilled TKD practitioner. The session was conducted by a World Taekwondo Federation 4th dan black belt qualified as a chief instructor and a 2nd dan black belt qualified as an assistant instructor. Children were also given a HEP to practice skills being taught.	Body Function: •SOT •UST	Three months of daily TKD training can improve sensory organization and standing balance for children with DCD. Clinicians can suggest TKD as a therapeutic leisure activity for this population.

Abbreviations; AVG, active video gaming; BOT-2, Bruininks-Oseretsky Test of Motor Performance-2; CAT-EI, Critical Appraisal Tool for Experimental Intervention Studies; CSAPPA, Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity Scale; CCT, Controlled Clinical Trial; CSQ, Coordination Skills Questionnaire; DCD, Developmental Coordination Disorder; DCDQ'07, Revised Developmental Coordination Disorder Questionnaire 2007; DSM-IV, Diagnostic Statistical Manual for Mental Disorders, version IV; DSM-5, Diagnostic Statistical Manual for Mental Disorders, version 5; dx, diagnosis; ERP, event-related potentials; FSM, functional strength measure; HEP, home exercise program; HHD, hand held dynamometry; ICF, International Classification of Functioning, Disability, and Health; MABC, Movement Assessment Battery for Children; MABC-2, Movement Assessment Battery for Children – Second Edition; MCT, Motor Control Test; MPST, muscle power sprint test; NTT, Neuromotor Task Training; PT, physical therapist; RCT, randomized CCT; SDQ, Strengths and Difficulties Questionnaire; SOT, Sensory Organization Test; TD, typically developing; TKD, taekwondo; UST, unilateral stance test; yo, years old; 3D, 3 dimensional

Supplemental Digital Content Evidence Table 14: Prognostic Studies for Children with DCD

Author, Year	AMSTAR Score/ Quality Rating	Aim	Date Range and Studies (participants)	Quality of Evidence	Population	Author conclusions
Adams et al., 2014	8 / High	The specific objectives of this systematic review were to:(i) conduct a systematic review of the DCD literature focused on the IMD hypothesis; (ii) examine the methodological quality of the relevant studies, (iii) describe whether the support for an internal modeling deficit is convincing enough to conclude it exists in children with DCD and (iv) make informed recommendations for future research.	Through 2013 (did not specifically state) Qualitative: 48 studies	Assessed using the CASP	Children 4 to 12.5 yo with DCD.	There is moderate support for deficits of predictive control in DCD which manifest across effector systems. The evidence for a deficit in the overt and covert control of eye movements, as well as covert manual action (motor imagery) was consistent and quite compelling
Magalhães et al., 2011	9 / High	To systematically review all literature published in peer reviewed journals in order to summarize and describe the activity limitations and participation restrictions of children with DCD.	January 1995 to July 2008 Qualitative: 44 studies	Did not formally appraise the evidence	Children with DCD	Evidence concerning activity and participation issues for children with DCD is limited in both volume and scope. Improved understanding of participation and of activity limitations in children with DCD is essential for clarifying diagnostic criteria, guiding assessment, and making evidence-based decisions regarding intervention. Researchers working with this population should make every effort to measure and consistently report the impact of children's motor impairments on function.
Rivilis et al., 2011	6 / Medium	A systematic review of the literature will be valuable in synthesizing the recent available data on fitness and physical activity in children with DCD, and in understanding the extent of the differences between children with DCD and typically developing peers	Through 2010 (did not specifically state) Qualitative: 27 studies with 1 fitness outcome (body composition, aerobic fitness, anaerobic fitness, muscle strength, power, or flexibility), 22 studies with physical activity as an outcome and 11 studies examined both.	These studies were reviewed in terms of: (a) study design, (b) population, (c) assessment tools, (d) measures, and (e) fitness and physical activity outcomes. Author did not list a specific method to examine the quality of evidence.	Children (3 to 18 yo) and Adults (20 to 60 yo) with DCD	It has been demonstrated that body composition, cardiorespiratory fitness, muscle strength and endurance, anaerobic capacity, power, and physical activity have all been negatively associated, to various degrees, with poor motor proficiency. However, differences in flexibility were not conclusive as the results on this parameter are mixed
*Wilson et al., 2013	8 / High	Summarize trends in the literature over the past 14 years and to identify and describe the main motor control and cognitive deficits that best discriminate children with DCD from those without.	January 1997 and August 2011 Qualitative: 129 (6204)	Did not formally appraise the evidence	Children with DCD (average age 9 yo), 2x as many boys as girls.	Across all outcome measures (Cohen's d=0.97), a moderate to large effect size was found, suggesting a generalized performance deficit in children with DCD. The pattern of deficits suggested several

						areas of pronounced difficulty, including internal (forward)modelling, rhythmic coordination, executive function, gait and postural control, catching and interceptive action, and aspects of sensory-perceptual function.
Zwicker et al., 2013	9 / High	Our primary aim was to present the current state of the evidence regarding the physical, psychological, and social QOL domains that can be affected in children with DCD.	Through November 2010 Qualitative: 41 studies	Author created quality assessment using the DSM-IV diagnostic criteria. Score of 4 if:1) reported a measure of motor impairment; 2) documented the impact of motor problems on ADLs; 3) excluded children with other neurological conditions AND ASD; 4) considered the child's intelligence. A score of 3 was given if 3 of the criteria was met; score of 2 if 2 criteria were met; and a score of 1 if only one was used to define DCD. High quality (4), Moderate quality (3), low quality (scores of 1 or 2).	Children or adolescents with DCD.	Children and youth with DCD are at risk for lower QOL than their typically developing peers. Although DCD has an impact across several QOL domains – physical, psychological and social – only one study at the time of this review had measured the multidimensional construct of QOL.

Abbreviations: ADLs, activities of daily living; AMSTAR, a measurement tool for the assessment of multiple systematic reviews; ASD, autism spectrum disorder; CASP, Critical Appraisal Skills Program; DCD, Developmental Coordination Disorder; DSM-IV, Diagnostic Statistical Manual for Mental Disorders; IMD, internal modeling deficit; QOL, quality of life; yo, years old
**Included a meta-analysis*