CLINICAL REVIEW

Developmental Coordination Disorder (Physical Therapy)

Indexing Metadata/Description

› **Title/condition:** Developmental Coordination Disorder (Physical Therapy)

› **Synonyms:** Motor dyspraxia; clumsy child syndrome; developmental dyspraxia; sensory integration dysfunction; perceptuo-motor dysfunction; disorder of attention and motor perception (DAMP); motor learning difficulty; coordination disorder, developmental (physical therapy); childhood coordination disorder (physical therapy); coordination disorder, childhood (physical therapy)

› **Anatomical location/body part affected:** Neuromusculoskeletal system, vestibular system, somatosensory system

› **Area(s) of specialty:** Pediatric Rehabilitation, Neurological Rehabilitation

› **Description:** According to the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*-5), 4 criteria must be met for a diagnosis of developmental coordination disorder (DCD): 1) performance in daily activities that require motor coordination is substantially below that expected based on chronological age and measured intelligence. This may be manifested by marked delays in achieving gross and/or fine motor milestones, poor handwriting, poor performance in sports, dropping things, or "clumsiness"; 2) criterion 1 deficits significantly and continuously interfere with academic achievement or ADLs appropriate to chronological age; 3) onset of symptoms is in the early developmental period; 4) the motor skills deficits are not explained by intellectual disability or visual impairment and are not attributable to a neurological condition affecting movement (e.g., cerebral palsy, muscular dystrophy, degenerative disorder). If intellectual disability is present, the motor difficulties supersede those expected for the mental age[(39)]

- Globally, the prevalence of DCD among children ages 5–11 years is 5–6%[(39)]
- Please see *Clinical Review…Developmental Coordination Disorder (Occupational Therapy)*, Topic ID Number: T708988, for specifics regarding evaluation and treatment from an occupational therapy perspective

› **ICD-10 codes**

- F82 specific developmental disorder of motor function

G-code Modifier	Impairment Limitation Restriction
CH	0 percent impaired, limited or restricted
CI	At least 1 percent but less than 20 percent impaired, limited or restricted
CJ	At least 20 percent but less than 40 percent impaired, limited or restricted
CK	At least 40 percent but less than 60 percent impaired, limited or restricted
CL	At least 60 percent but less than 80 percent impaired, limited or restricted

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CM	At least 80 percent but less than 100 percent impaired, limited or restricted
CN	100 percent impaired, limited or restricted
Source: http://www.cms.gov	

(ICD codes are provided for the reader's reference, not for billing purposes)

› **G-codes**

- **Mobility G-code Set**
  - G8978, Mobility: walking & moving around functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8979, Mobility: walking & moving around functional limitation; projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8980, Mobility: walking & moving around functional limitation, discharge status, at discharge from therapy or to end reporting
- **Changing & Maintaining Body Position G-code Set**
  - G8981, Changing & maintaining body position functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8982, Changing & maintaining body position functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8983, Changing & maintaining body position functional limitation, discharge status, at discharge from therapy or to end reporting
- **Carrying, Moving & Handling Objects G-code Set**
  - G8984, Carrying, moving & handling objects functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8985, Carrying, moving & handling objects functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8986, Carrying, moving & handling objects functional limitation, discharge status, at discharge from therapy or to end reporting
- **Self Care G-code Set**
  - G8987, Self care functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8988, Self care functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8989, Self care functional limitation, discharge status, at discharge from therapy or to end reporting
- **Other PT/OT Primary G-code Set**
  - G8990, Other physical or occupational therapy primary functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8991, Other physical or occupational therapy primary functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8992, Other physical or occupational therapy primary functional limitation, discharge status, at discharge from therapy or to end reporting
- **Other PT/OT Subsequent G-code Set**
  - G8993, Other physical or occupational therapy subsequent functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8994, Other physical or occupational therapy subsequent functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8995, Other physical or occupational therapy subsequent functional limitation, discharge status, at discharge from therapy or to end reporting

› **Reimbursement:** Reimbursement for therapy will depend on insurance contract coverage. Children in the United States may qualify for state-funded early intervention programs and/or school-based therapy services. Controversy exists about how much accommodation should be provided in school for children with DCD (e.g., whether to promote extensive practice to improve handwriting or to provide word-processing keyboards)[48]

› **Presentation/signs and symptoms:** Specific manifestations of DCD are varied, pervasive, and may affect gross motor skills, fine motor skills, academic learning, and social-emotional skills[2,3,4,48]

- Primary caregivers report the following:[1,36,37]
  - Delayed gross motor skills, including sitting up, reciprocal creeping, walking, ball skills, and jumping
  - Problems with sucking and swallowing during the first year of life
  - Clumsiness, frequent falling or tripping, running into other children
  - Poor coordination
  - Difficulty dressing
  - Difficulty following directions
  - Poor balance
  - Speech and language delays
  - Fine motor difficulties: dysgraphia (difficulty with hand writing), using scissors, tying shoelaces
  - Dyspraxia: verbal, constructional, motor
  - Poor spatial awareness or proprioception
  - Difficulty with motor planning and sequencing tasks
- Developmental delays may be mild at an earlier age and become more apparent as affected children enter primary school due to the increased physical, social-emotional, and cognitive demands[1]
- Cognitive and behavioral delays may become more apparent as a child ages due to frustration with poor motor skills, low self-esteem, and social isolation[1]
- Children differ greatly with respect to the apparent age of onset of DCD and developmental progression; most often DCD does not fully present until school age as a result of a greater need to acquire skills that require adaptations in speed, timing, force, or distance of movement[1]

Causes, Pathogenesis, & Risk Factors

› **Causes**

- Etiology is unknown. Some theories suggest a peripheral nervous system defect or delay while others suggest a CNS dysfunction, particularly a cerebellar dysfunction. However, the neural basis of DCD remains unclear at this time[1,39]
- Sensory deficits associated with DCD may result from dysfunction in CNS processing involved in planning, organizing, and timing of motor responses. Failure to anticipate sensory input cues or use perceptual information for movement may be related to inadequate or poor CNS processing[6]

› **Pathogenesis**

- Largely unknown due to the complexity of the disorder and unknown etiology
- In theory, skilled movements require a program of action with a specified objective. There is a sequence of hierarchically organized pathways within the central and peripheral nervous system. Once motor skills are acquired, they become adaptable. For example, a child who has learned to walk can do so on varied terrain. A child with DCD has significant difficulty learning an age-appropriatemotor skill and then adapting it to a variety of situations. Why and how this occurs is still unknown[36]

› **Risk factors**

- Affects males more often than females with a ratio between 2:1 and 7:1[39]
- Premature birth, especially with extremely low birth weight (ELBW) for gestational age, with prevalence rate of 30.7–51% for children with a history of prematurity[1]
  - Authors of an Australian cohort study found a DCD prevalence of 42% among “apparently normal,” extremely premature children (< 29 weeks) or ELBW schoolchildren compared with 8% for matched full-term peers[5]
    - Prolonged rupture of membranes and retinopathy of prematurity were found to be significantly and independently associated with DCD
  - Perinatal variables significantly associated with DCD included male sex, lower gestational age, and lower birth weight in a retrospective study conducted in Canada in a cohort of very low birth weight (VLBW; ≤1250g) children followed in a hospital neonatal follow-up program[33]
    - Between May 2005 and October 2009, 157 children aged 4–5 years met the inclusion criteria

- From this cohort, 42% were identified as having DCD based on a score of ≤15th percentile on the Movement Assessment Battery for Children (MABC)
- Only male sex and low birth weight independently predicted DCD
- Boys performed more poorly than girls on all subtests of the MABC
- Compared to children in the cohort without motor impairment, children with DCD had greater postnatal steroid exposure, longer ventilation duration, greater number of days with supplemental oxygen, and significant retinopathy of prematurity (grade 3, 4, or laser treated)
- Postnatal steroid exposure was the only statistically significant factor

• Fetal exposure to alcohol or drugs (e.g., cocaine or methamphetamine)[39]

• Genetic influences[48]

Overall Contraindications/Precautions

› Be aware that the clinical presentation of children with DCD is heterogeneous. They may differ
- • in the degree of involvement (mild to severe)
- • in the extent to which the disorder affects ADLs (reading, dressing, grooming)
- • in specific motor skills – gross motor delays (postural stability, strength, activity level) and/or fine motor delays (eye-handcoordination, handwriting)
- • in the extent to which the disorder affects their attention

› The presence of comorbid conditions, such as attention-deficit/hyperactivitydisorder (ADHD) or autism spectrum disorder (ASD), can make the evaluation and treatment sessions more challenging and can delay the child's ability to gain independence with ADLs[39]

› See specific **Contraindications/precautions to examination** and **Contraindications/precautions** under **Assessment/ Plan of Care**

Examination

› **Contraindications/precautions to examination**
- • A multidisciplinary team assessment may be the best approach when evaluating children with DCD due to the complexity and variability of their functional impairments and activity limitations. The team of rehabilitative therapists may include physical therapists (PTs), occupational therapists (OTs), speech-language pathologists (SLPs), and psychologists/ neuropsychologists[11]
- • The initial evaluation should be conducted in the most minimally threatening manner in hopes of limiting future anxiety and resistance to treatment intervention. Primary caregivers ideally should be present during the evaluation
- • Any neurological or connective tissue disorder should be ruled out, including muscular dystrophies, cerebral palsy, brain tumor, epilepsy, Friedreich's ataxia, and Ehlers-Danlos syndrome[1,3]
- • Specific developmental assessments are used to determine the presence of DCD, but they should not be used alone to make or rule out the diagnosis. Refer to the patient's primary physician if any abnormal neurological and/or behavioral signs exist or there is parental report of loss of gross/fine motor skills
- • Pain is not a common complaint in children with DCD; however, respect their need for rest breaks since fatigue is a common symptom

› **History**
- • **History of present illness/injury**
  - –Ask parent/primary caregiver about the chronological age at which specific developmental milestones were met, including rolling, reciprocal creeping, walking, running, jumping, talking, self-feeding, self-dressing, and toileting, to establish patient's baseline motor development
  - –**Course of treatment**
    - **Medical management**
      - Medical management typically involves referral to rehabilitative services
      - In some cases, parents will report being told to "wait and see" or "not to worry" by their primary care physician despite expressing that "something was not quite right" with their child[1]
    - **Medications for current illness/injury:** Determine what medications clinician has prescribed; are they being taken? Does the child experience any side effects? If so, describe

- **Diagnostic tests completed:** In most children, DCD is not diagnosed. There is no "gold standard" diagnostic procedure that can be used alone to confidently identify DCD. Children are more likely assessed and identified as meeting criteria for DCD according to research study objectives rather than through a comprehensive diagnostic process[1,11]
  - Formal diagnosis is made by a physician when DCD criteria are met as outlined in the*DSM*-5;[3,39] please see *Description*, above
  - Visual and auditory testing may be indicated to rule out any visual or auditory disorders as causes of developmental delays[1]
  - Kaufman Brief Intelligence Test, 2nd ed. (KBIT-2): screening tool measuring verbal and nonverbal cognitive functions in 3 subtests
    - Quick, valid, and reliable measure of intelligence measured by health professionals who are not psychologists (i.e., below average, average, above average scores for cognitive functioning)
    - Recommend referral to psychologist for further evaluation if KBIT-2 score is < 80[3]
- **Home remedies/alternative therapies:** Document any use of home remedies or alternative/complementary therapies (e.g., acupuncture, herbal supplements, craniosacral therapy) and whether or not they were helpful with symptom relief
- **Previous therapy:** Document whether patient has received prior rehabilitative services, such as physical therapy, occupational therapy, speech pathology, neuropsychology, or behavioral therapy; if so, document time frame and specify which treatment interventions were helpful or not helpful. Children may have received therapeutic intervention in the past through early intervention even if DCD was not specifically diagnosed. The majority of children are referred for therapeutic intervention during the early years of primary school, often due to immature and laborious handwriting, difficulty performing ball skills, and difficulty copying from the blackboard[1]

– **Aggravating/easing factors:** What situations seem to exacerbate or ease/improve the symptoms?

– **Nature of symptoms:** Document nature of symptoms. Parents often report child is clumsy or awkward, fatigues quickly, has difficulty with handwriting, frequently drops things, and seems unaware of environment[39,48]

– **Other symptoms:** Document other symptoms patient may be experiencing that could exacerbate the condition and/or symptoms that could be indicative of a need to refer to physician (e.g., dizziness, attention deficit)

– **Barriers to learning**
  - **Are there any barriers to learning? Yes__ No__**
  - **If Yes, describe _____**

• **Medical history**

– **Past medical history**
  - **Previous history of same/similar diagnosis:** Does the patient have a history of sensory integration disorder, dyspraxia, speech-languagedelay, developmental delay, or hypotonia?
  - **Comorbid diagnoses:** Ask patient or parents/caregivers about other problems, including ADHD, dyslexia, ASD, academic learning difficulties (reading/writing), orthopedic injury, speech-language disorder, diabetes, obesity, heart disease, psychiatric disorders, and emotional and behavioral difficulties
    - ADHD is the most frequent co-existingcondition, with ~50% co-occurrence. Those in whom ADHD and DCD are diagnosed typically demonstrate more impairments or greater severity of impairments than individuals with ADHD alone[39]
    - DCD may be a precursor of overweight/obesity and may increase the risk of diabetes mellitus, type 2 (DM2) and hypertension[3]
  - **Medications previously prescribed:** Obtain a comprehensive list of medications prescribed and/or being taken (including OTC drugs and homeopathic medicines)
  - **Sleep disturbance:** Inquire about child's sleep patterns. Children with DCD are more likely to have sleep disturbances (e.g., parasomnias) and resistance to going to sleep[12]
  - **Other symptoms:** Ask patient and/or caregiver about other symptoms he or she may be experiencing

• **Social/occupational history**

– **Patient's goals:** Document what physical activities or functional skills the patient and/or primary caregiver want to improve with therapy intervention
  - Parents and children typically report that their primary goal is for the child to be able to participate in social and physical activities[27]

- Perceived Efficacy and Goal Setting System (PEGS): Enables the child (age 5 years and older) to actively participate in goal setting based on his or her perceived competence performing gross and fine motor skills[1]
- Authors of a 2015 systematic review stressed that health care providers should help children and families to develop realistic expectations. Goals should encompass different aspects of the children's lives, including the development of learning and coping strategies, as well as support and strategies for transition to adulthood[49]
  - It was noted that within current delivery systems goals are often planned by professionals without sufficient family or child input, and that interventions may be focused more on remediation of impairment than on function
  - As DCD is a lifelong condition, identifying goals that shift the focus toward fostering function and participation and preventing secondary complications is recommended[49,53]

– **Vocation/avocation and associated repetitive behaviors, if any:** Does the patient attend school/home school? Do the patient and family have a strong support network? Does the patient have hobbies or special interests? Does the patient participate in group activities (e.g., church groups, Boy/Girl Scouts)? Does the patient have friends and meaningful peer relationships? How much daily physical activity does the patient typically do?
- Using accelerometers to record physical activity, researchers in Canada found that children with DCD spent significantly less time in moderate to vigorous physical activity than typically developing children. Separate multivariate regressions by gender showed that the direct effect of DCD on physical activity occurred in boys more than in girls[50]
- Children with DCD often have difficulty participating in activities that require greater precision, continuous adaptability, and eye-hand coordination (e.g., throwing, catching, kicking, playing an instrument)[7,40,41]
- DCD is a risk factor for poor peer relationships because social life is often limited due to decreased age-appropriate physical activity/play[40,41]
- Children with DCD typically have a lower level of social participation than typically developing children of the same age and sex[41]
  - Results from a Canadian cross-sectional study of 27 children ages 5 to 13 years indicated that children with DCD have significantly lower levels of lifestyle achievement in all categories of life habits based on the LIFE-H assessment. These include interpersonal relationships, responsibilities, recreation, education, mobility, fitness, personal care, nutrition, housing, and communication compared to those in an age- and sex-matched control group. The greatest discrepancy was in education and communication
- Play is important for childhood development. Children with DCD are reported to be less involved in play and more socially isolated than their typically developing peers[40]
  - Based on results from a controlled, comparative study of Australian preschool children (ages 4 to 6 years), children with DCD had impaired play skills (e.g., delayed social play, impaired cooperation within play, participated in less mature forms of play, delayed verbal play) and engaged less frequently in play activities than their typically developing peers as measured by review of a 30-minute videotape using the Revised Knox Preschool Play Scales and the Play Observation Scale. This can have a significant impact on a child's global development at an early age

– **Functional limitations/assistance with ADLs/adaptive equipment:** Parents often report their child having difficult performing age-appropriate ADLs such as dressing, feeding, hygiene, and other self-careroutines[3]
- Developmental Coordination Disorder Questionnaire (DCDQ): parent questionnaire screening tool designed to identify subtle motor problems in children aged 5–15 years[13,14,15]
  - Three categories: postural control during movement, fine motor/handwriting, and general coordination
  - Valid and reliable clinical screening tool for children with DCD; its predictive value is excellent, with 84.6% sensitivity and 70.8% specificity[29]
  - Some studies indicate DCDQ is better at identifying moderate to severe DCD than mild DCD
  - Recommended as an adjunct to standardized tests to rule out motor delays
- Vineland Adaptive Behavior Scales, Second Edition (VABS-II): parent/patient questionnaire used to measure adaptive behavior, which is defined as the typical performance of daily activities required for personal and social sufficiency[29]
  - Norm-referenced values for newborns through adulthood
  - Four domains: communication, daily living skills, socialization, and motor skills
  - Maladaptive behavior domain can be completed if there is a need to assess any problem behaviors
- Pediatric Evaluation of Disability Inventory (PEDI): standardized assessment tool measuring functional self-care, social, and mobility activities[11]

– **Living environment:** With whom does the patient live (e.g., family members, caregivers)?

- Are there any barriers within the home to patient's independence? Ask if any modifications are necessary, such as stairs, and if so the number of floors in home. Entrance to the home? Shower vs. bathtub?

› **Relevant tests and measures: (While tests and measures are listed in alphabetical order, sequencing should be appropriate to patient medical condition, functional status, and setting)**

- **Anthropometric measurements:** Assess BMI and compare to age- and gender-matched values
  - Children with DCD are at an increased risk for developing obesity compared to children without DCD
    - Australian researchers compared physical activity level, body composition, strength, and cardiovascular fitness of 9 children with DCD to a group of 9 age- and gender-matched peers (mean age 8 years, 10 months)[35]
      - Children with DCD had significantly higher BMIs; 6/9 were classified as overweight or obese compared with only 2/9 of the children without DCD
- **Arousal, attention, cognition (including memory, problem solving):** Patient may have difficulty with task completion, attention, and organization[3]
  - Child Behavior Checklist (CBCL): 120-item parent questionnaire assessing behavioral and emotional problems during the previous 6 months for children aged 2–18years[4]
    - Easily administered in order to assess need for psychology referral and assist with treatment intervention
- **Assistive and adaptive devices:** Is the patient currently using any adaptive equipment to assist with ADLs?
- **Balance:** Assess patient's static and dynamic balance with one or more of the following tests as deemed appropriate for the setting and patient's age:
  - Common tests: Bruininks-Oseretsky Test of Motor Proficiency (BOT), Second Edition (BOT-2) balance subscale, Pediatric Balance Scale (PBS), MABC or MABC-2, computerized posturography system[6,11,16]
  - Poor postural control and balance is one of the most common features (73–87%) of children with DCD[6]
  - At ages 5–8 years there is a significant developmental period in postural control during which changes in strategy and performance occur through sensory reweighing[5,6]
    - Girls tend to be more proficient in static balance tasks than boys until age 7–8; both genders level off around age 8 years[5]
  - Researchers consistently describe a "slowness of movement," with delays noted in aiming and timing tasks (both reaction and movement time), when balance is being challenged compared to typically developing children
    - Movement patterns may not be as "automatic"; less effective muscle activation patterns are used[3,5]
  - Some studies indicate that children with DCD rely more heavily on vision than other senses in order to control movement well beyond the age at which typically developing children would[3,5]
    - Visual-information processing deficits may be a problem for these children when performing balance activities
    - Slower response than typically developing children when performing different visual-spatial attention tasks
  - In a study conducted in Canada, 22 children (7 to 14 years of age) with DCD demonstrated significantly less anticipatory activation of postural control muscles, contributing to their impaired dynamic stability and poor quality of movement[43]
    - Children with DCD demonstrated less anticipatory muscle activation with their ipsilateral tibialis anterior, ipsilateral transversus abdominis/internal oblique and bilateral external oblique muscles during three motor skills (kicking a ball, stepping onto a step, and standing on one foot) compared to a control age- and sex-matched group
    - Children with DCD activated these muscles ¼ to ½ as often as the control group did while performing the same tasks
- **Cardiorespiratory function and endurance:** Increased fatigue compared to peers without DCD is often reported, most likely resulting from decreased strength, inefficient movement patterns, and avoidance of physical activity. Poorer performance is reported in physical fitness tests with high demands on coordination compared to peers; this difference increases with age[3,5,7]
  - Use the 6-minute walk for distance test (6MWT) or 20-m sprint for aerobic and anaerobic endurance measures
    - Measure pre- and post-testing heart rate (HR) and blood pressure (BP)
    - May also asses patient's level of exertion using dyspnea scale and/or Modified Borg Scale
- **Functional mobility** (including transfers, etc.): Assess basic ADLs and level of assistance required to safely perform skills such as transfers, bed mobility, grooming, dressing, toileting, etc.
  - The Timed Up and Go (TUG) test, Timed Up and Down Stairs (TUDS) test, and/or Pediatric Evaluation of Disability (PEDI) can be used as appropriate per patient's age, evaluation setting, and functional limitations
- **Gait/locomotion:** Assess patient's gait and note any significant deviations such as toe walking, decreased reciprocal arm swing, decreased speed, extent of falling or loss of balance, etc.

– Australian researchers compared running gait in children with (n = 14) and without DCD (n = 14)[45]
  - Children in the DCD group displayed decreased peak knee extension compared with the control group prior to initial contact
  - The children in the DCD group displayed increased variability in sagittal plane kinematics at the hip and ankle during toe off compared with the control group
  - There were significantly decreased knee extensor moments during the stance phase of the running cycle in the DCD group, resulting in significant reduction in peak knee power absorption and ankle power generation
  - Trend was seen for children with DCD to have shorter strides and longer stance phases than the control group

• **Joint integrity and mobility:** Assess UE and LE joint mobility. Joint hypermobility commonly co-occurs with DCD.[39]

Document degree of joint hypermobility using the Beighton Hypermobility Scale[17]

– Researchers in the Netherlands found an association between joint hypermobility and motor performance in children with DCD[42]
  - Hypermobility is defined as a Beighton score ≥5 for children 3–9 years of age and ≥4 for individuals ages 10 through 16 years
  - Thirty-six children and adolescents with DCD were compared to 352 randomly selected typically developing children and adolescents
  - The mean Beighton score for children 3–9 years of age was 5.0 versus 2.9 in the control group. The prevalence of hypermobility was higher in the DCD group (64% vs. 33%)
  - A negative correlation was established between Beighton score and total MABC scores within the DCD group but not in the control group. Specifically, a statistically significant negative correlation was found between the MABC total score and degree of knee hyperextension in those with DCD
  - Researchers recommend that an international agreement be established on firm cutoff points for hypermobility with the Beighton scale

• **Motor function (motor control/tone/learning)**

– May present as stiff, awkward, and clumsy, often resulting from "fixing" joints (i.e., holding a joint immobile as a means of stabilization so that another joint can be moved)

– May present with mild hypotonia throughout the trunk and/or extremities[48]

– Children with DCD have difficulty selecting the best motor response for a given task and may repeat motor tasks in the same way regardless of their success
  - Decreased adaptability and flexibility in motor behavior/motor learning, tending to rely on feedback while the movement is occurring (i.e., visual) vs. developing anticipatory responses
  - Learning new tasks is more demanding since children with DCD do not interpret and utilize sensory feedback or feedback from task performance in the same manner as typically developing age-matchedpeers[18]

• **Muscle strength:** Manual muscle testing (MMT) may not be appropriate to assess bilateral UE, LE, and trunk strength based on the child's age and ability to follow commands

– Typically present with decreased strength and power either as a primary and/or secondary impairment[3,5,19]

– May assess strength by incorporating the "make test," requiring the child to exert a maximal isometric contraction against a handheld dynamometer
  - No reference values for children with DCD and/or the general pediatric population[19]

– May use functional strength testing that is age appropriate, such as number of sit-ups and/or push-ups, medicine ball throw, broad jump, vertical jump, and/or single-leg hop test[19]

• **Neuromotor development:** Utilize assessment tools such as the PEDI; Peabody Developmental Motor Scales, Second Edition (PDSM-2); BOT-2; or MABC

– MABC/MABC-2: 4 subtests (manual dexterity, ball skills, static balance, dynamic balance) that indicate overall motor impairment[3,6]
  - Normative test with good reliability and concurrent validity
  - Total score of < 15% indicates significant motor impairment and total score < 5% indicates severe motor impairment
  - Subtle postural control problems may be missed; more specific balance/postural control tests may be indicated[6]
  - May penalize children with learning and attention problems[3,6,10]

– Common gross motor difficulties involve running, jumping, hopping, galloping, skipping, throwing, and catching[39,48]

  - Common fine motor difficulties involve printing, handwriting, and managing fasteners (buttons, snaps, zippers)[39,48]
  - Patients often present with lack of fluidity of movement and decreased speed
  - Patients often have impaired upper extremity coordination[20]
- **Perception** (e.g., visual field, spatial relations): Assess UE and LE static and dynamic position sense testing. Visual-spatial processing, visual-kinesthetic integration, and kinesthetic perception are all often reported to be impaired. More specific testing may be necessary to properly identify the impairments and may be best addressed by occupational therapy, neuropsychology, and/or vision therapy[7]
- **Posture:** Visually inspect patient's standing and seated posture and note any abnormalities/asymmetries
- **Range of motion:** Assess bilateral UE and LE AROM and PROM. Note any abnormality
- **Reflex testing:** Assess bilateral C5, C6, C7, L4, and S1 and note any abnormality
- **Self-care/activities of daily living** (objective testing): Common ADLs requiring eye-hand coordination are often impaired: dressing, feeding, hygiene, handwriting, and cutting; referral to occupational therapy is warranted[3,21]
- **Sensory testing:** If sensory integration difficulties are suspected, a formal occupational therapy referral is warranted
- **Special tests**
  - Some of the more common physical therapy assessments are PDSM-2, BOT/BOT-2, MABC/MABC-2, DCDQ, and PEDI[1,22]
    - MABC is a valid and reliable test used to assess motor skill performance in children. DCD is diagnosed if their total score is < 5%. A total score of 5–15% indicates children are at risk for DCD. A total score of > 15% is considered normal motor performance[9,23]
    - DCDQ has been shown to be valid and reliable; however, authors of an Australian study found that the MABC and the DCDQ were only modestly effective in accurately diagnosing DCD, with a high rate of false positives and false negatives using the recommended cutoffs for each test[13]

Assessment/Plan of Care

› **Contraindications/precautions**

- **Only those contraindications/precautions applicable to this diagnosis are mentioned below. Rehabilitation professionals should always use their professional judgment**
- **Patients with this diagnosis are at risk for falls due to decreased balance and postural control; follow facility protocols for fall prevention and post fall-preventioninstructions at bedside, if inpatient. Ensure that patient and family/caregivers are aware of the potential for falls and educated about fall-prevention strategies. Discharge criteria should include independence with fall-preventionstrategies**
- Clinicians should follow the guidelines of their clinic/hospital and what is ordered by the patient's physician
- The summary below is meant to serve as a guide, not to replace orders from a physician or a clinic's specific protocols
- It is important to be in direct communication with the referring physician and other rehabilitation staff regarding the patient's course of treatment

› **Diagnosis/need for treatment:** DCD should be diagnosed only if the child's motor incoordination causes a significant functional limitation in performance of an everyday skill that is expected or valued by children of that same age and measured intelligence. The diagnosis is made exclusively based upon the results of assessments of a child's performance on a series of standardized tests such as those discussed above (e.g., MABC-2, BOT-2, VMI). Early diagnosis, treatment, and educational support are extremely important in addressing the needs of children with DCD. Ideally these should occur prior to a child entering kindergarten

- Physicians often do not know how to properly identify coordination difficulties and subsequently DCD may go undiagnosed. Proper education is needed in order to diagnose DCD in children earlier and provide treatment intervention[49]
- Parents may spend months or years seeking a diagnosis in order to obtain proper medical and educational treatment intervention and support[31]
  - Canadian researchers measured the current awareness and knowledge of DCD among parents of children aged 3–12 years, teachers of children aged 5–12 years, pediatricians, and family/general physicians working in the community with at least 15% of their patients being children[31]
    - A short online survey of 1,297 participants was completed between December 2010 and February 2011

- Parent and teacher sample was drawn from a Canadian national market research and public opinion panel and the physician sample was recruited primarily from Canada and the United States (50% and 42%, respectively) and the United Kingdom (8%)
- Less than 33% of the general physicians and only 41% of the pediatricians were familiar with DCD
- The majority of physicians and teachers (70%) were able to identify common physical characteristics of DCD, but less than 30% were knowledgeable about the psychological and secondary consequences of DCD (low self-esteem, poor physical fitness, poor social skills, anxiety, depression)
- Less than 25% of the pediatricians and 9% of the general physicians had diagnosed DCD
- Although 70% of parents were confident that their child's physician would accurately and quickly diagnose a specific condition, only 30% of physicians believed that diagnosing DCD would be relatively easy
- Results confirm observations by clinicians and researchers that DCD is not well known and that many children are likely to be "missed" or the condition misdiagnosed

• Developmental questionnaires and screens are useful tools that parents, teachers, and primary care providers can use to assist in making proper diagnosis[1]

• Rehabilitation therapists need to include active participation in social communication and facilitate the development of conversation skills and social interaction in order to improve peer relationships in school and recreational settings[41]

› **Rule out:** DCD can be diagnosed only if any underlying musculoskeletal/neurological disorders have been excluded as the cause of the child's developmental delays[1,36]

› **Prognosis:** DCD is not a progressive disorder; however, difficulties/delays in motor skills often continue into adulthood. Children with DCD show higher rates of social difficulties, low self-esteem, and associated behavioral problems during childhood, adolescence, and early adulthood[30]

• Children do not outgrow DCD, but physical developmental delays become less apparent as they enter high school because they can limit participation in physical activities[1]

• Research indicates that children with DCD will avoid physical activity (sports or leisure), which reduces their opportunities for social interaction and decreases their physical fitness throughout life

– Failure to diagnose DCD and provide therapeutic intervention may result in major difficulties in childhood and into adulthood, including unemployment, psychiatric disorders, substance abuse, poor interpersonal skills, and criminality. The more severe the condition, the greater the chance of problems persisting into adulthood[1,3,24]

• Low levels of physical activity and fitness have also been associated with below-average bone strength and fracture risk in adolescents with DCD[52]

• Children with DCD with poor motor coordination and who had normal birth weight have increased odds of developing major depressive disorders and generalized anxiety disorders through adulthood[55]

› **Referral to other disciplines:** Children with DCD often present with difficulties in multiple areas (gross motor, fine motor, speech, peer interaction) and benefit from a multidisciplinary team approach, with each healthcare professional performing his/her own formal evaluation. This will provide the most comprehensive description of the child's functional performance, which is essential for optimal intervention planning. This may include neuropsychology, psychology, behavior therapy, occupational therapy, and/or speech-language therapy evaluations, especially when there are concerns regarding attention, learning difficulties, and/or social-peerinteractions[1,8,10]

• Referral to OT to address fine motor skills and self-maintenance/ADLs[21]

• Referral to SLP may be necessary for receptive and/or expressive language disorders

• Referral to psychology or individual or group therapy to help children and adolescents cope with their motor impairments and decreased self-esteem[1]

– Boys with DCD tend to have a significantly lower self-concept(evaluative and descriptive aspects of oneself) of their physical abilities and peer relations compared to boys without DCD. The more severe their motor impairments, the lower their self-concept of their physical abilities[25]

– Australian researchers found that boys with DCD aged 10–13years reported significantly higher loneliness and lower participation rates in all group physical activities, whether structured (team sports) or unstructured (informal outdoor play), than boys without DCD

- Team sports may still be beneficial for children with DCD; the potential for success is greatest when both the child's physical and emotional needs are met in a team-based setting[26]

- Referral to neuropsychology/psychology for formal evaluation if the child scores < 80 on the KBIT-2[3]

• Referral to vision therapist and neuro-ophthalmologist for formal evaluation
- Studies indicate that children with DCD can present with visual impairments which can significantly affect their balance, motor skills, and education
- In a small study, researchers in France found that children with DCD can have delayed maturation of visual smooth pursuit eye movements, which impact the child's visual spatial and visual motor systems, compared to a control group of typically developing children (7 to 12 years of age). Smooth pursuit eye movements are continuous eye movements that "keep the line of regard congruent with the line of interest"[44]
- South African researchers concluded that an 18-week visual therapy program at a frequency of once a week for 40 minutes per session can significantly improve visual impairments in children with DCD as measured by the Sensory Input Systems Screening Test and Quick Neurological Screening Test, Second Edition[47]
  - Thirty-two children (7 to 8 years of age) with DCD participated in this crossover design study
  - Following the 18-week program, a 75% to 100% improvement in visual pursuit, fixation, ocularalignment, and convergence occurred, with significant long-term effects

• Parents may also benefit from a psychology referral in order to discuss their concerns and feelings regarding raising a child with DCD

› **Other considerations**

• It is not uncommon for parents to be frustrated by the lack of knowledge and expertise of healthcare professionals in the diagnosis and treatment of DCD. There is often a lack of support services, and parents may be unaware of the resources available to them through their local community or the Internet. It is very important to include the parent and child when developing goals and treatment interventions. Clinicians need to educate teachers, physicians, and other community members regarding DCD[49]
- Researchers in the United Kingdom conducted semi-structuredinterviews with a sample of 12 parents of children with DCD in order to explore the experiences of parents living with a child with DCD[34]
- DCD impacts all aspects of family life, which can be perceived by the parents as complex, frustrating, and overwhelming. They report being angry, in denial, and depressed
- Parents reported that their concerns regarding developmental motor delays were often dismissed by the child's physician

• Child may require increased encouragement to actively participate in therapy due to prolonged period of feeling unsuccessful/incompetent in motor skills[51]

• Authors of a study conducted in Australia suggested that a group intervention program managed by either a healthcare professional (e.g., PT) or a school assistant (supported by a PT) in either a clinical setting or school environment can achieve successful outcomes in improvements in the MABC[56]
- Ninety-three children were randomized to a 13-weekgroup-based task-oriented intervention and placed in either the school setting managed by a school assistant and supervised by a PT or a health clinic run by a PT
- Results show that both groups demonstrated significant improvements in motor skills for all modes of delivery lasting up to 6 months post-intervention

› **Treatment summary**

• During the period 2004–2006, several professionals from different countries met to obtain a new agreement regarding DCD diagnosis, research, and intervention, resulting in the Leeds Consensus statement in 2006. The consensus established the following guidelines for intervention approaches[30]
- Activities should be functional, based on goals that are relevant to daily living and meaningful to the child
- Treatment interventions should enhance generalization and application in the context of everyday life
- Interventions must be evidence-based and grounded in the theories that are applicable to understanding children with DCD

• There are two main treatment approaches for DCD: process oriented and task oriented
- The process-oriented approach focuses on developing the components or sensory modalities needed to perform functional activities through sensory integration (SI), kinesthetic (movement perception) training, perceptual training, or a combination. This is also described as a bottom-up approach to learning[1,4,30]
- The task-oriented approach focuses on specific functional skills through direct practice based on dynamic systems theory, with the ultimate goal of improving functional motor task performance in learned daily life skills. This is also described as a top-down approach to learning[1,4]

- All treatment approaches should emphasize improving a child's self-esteem[1]

- Process-oriented approach
  - Children with DCD do not interpret and utilize sensory feedback or feedback from task performance in the same manner as children who are typically developing
  - Tasks requiring heavy reliance on integrating feedback from the senses and those requiring constant monitoring of feedback during task performance will be more difficult to master
  - SI/process-oriented treatment approaches focus on stimulating the sensory systems (e.g., visual, tactile, vestibular) so that children learn to integrate the sensory information into appropriate motor responses and thus have better skill performance[30]
  - In clinical reviews of studies investigators found limited effectiveness for process-oriented treatment approaches in children with DCD[19,28]
- Traditional physical or occupational therapies combine process-oriented approaches with direct skill training with the underlying assumption that motor skills are developed in a hierarchical pattern[30]
  - Basic abilities (such as postural control, visual-perceptualskills) need to be refined in conjunction with teaching complex motor skills in order to master the motor task
- Task-specific interventions are useful for gross/fine motor skill development and indirectly enhance general participation in physical activity. There is an emphasis on motor performance (i.e., learning a specific motor skill), with attention given to specific aspects of task performance that are difficult for the child to master[28,30]
  - Examples of task-oriented treatment approaches are neuromotor task training (NTT), cognitive orientation to daily occupational performance (CO-OP), and imagery training[30]
  - All task-oriented treatment approaches are based on a combination of current motor control or motor learning principles and environmental principles[30]
  - NTT, developed in the Netherlands, is based upon motor control and motor learning principles with an emphasis on motor planning and task initiation[28]
    - Emphasizes that task structure and scheduling are fundamental to the way skills are assembled over repeated learning trials. It also considers how the task and environmental constraints can be manipulated to provide a means for the child to master the skill[30]
    - Standard protocol is used to first assess strengths and weaknesses of a child's functional performance and then analyze which cognitive or motor control processes might be involved in the deficient skills, such as attention deficit, fear of failure, lack of motivation, lack of understanding of how to execute the skill, timing of movement, motor planning, and speed and force of movement
    - Task-oriented treatment approach focuses directly on teaching the skills a child needs in daily life through functional exercises. The greater the resemblance between skills and the circumstances practiced during treatments, the more likely success in learning the desired functional skill
    - Cognitive strategies are not explicitly taught; rather, tasks are trained in various, gradually more challenging activities[4,28]
- Canadian therapists developed the task-specific treatment approach Cognitive Orientation to daily Occupational Performance (CO-OP). It can be considered the most pure example of a top-down treatment approach to motor learning[30]
  - CO-OP focuses on the use of cognitive strategies to facilitate skill acquisition using a collaborative, problem-solving approach adapted from cognitive-behavioraltherapy, particularly the work of Meichenbaum[30]
  - Children learn to ask questions about their own performance and problem solve to find their own answers to questions. Motor skill learning is enhanced by teaching problem-solvingtechniques
  - Children are encouraged to form a mental model of how to attack a movement task; they are led to generate a movement goal, plan its implementation, and reflect on how their performance was or was not successful (goal, plan, do, check)[30]
  - Goal is to enhance motor learning outside of the therapy program and in daily life
- Belgian researchers conducted a systematic review of studies on therapeutic treatment interventions for children with DCD published between 1995 and December 2011 in order to determine the most effective treatment strategy[30]
  - Twenty-six studies met the inclusion criteria for the systematic review and20 of these met the criteria for the meta-analysis

- There were strong effects for task-oriented intervention (0.89) and traditional physical and occupational therapies (0.83) and a weak effect size for process-orientedintervention (0.12)
- Post-hoc comparison showed that the effect size of the task-oriented approaches(NTT and CO-OP) was significantly higher than the effect size of process-orientedintervention
- There is only 1 published article regarding motor imagery training, so researchers advise caution when considering the efficacy of motor imagery training for treatment intervention
- Individual and group task-oriented programs were both effective ways of teaching motor skills
- Researchers do not recommend process-oriented approaches for improving motor performance in children with DCD. There have been other meta-analyses and systematic reviews evaluating the efficacy of sensory integration treatment; however, there has been very little published since 1994 and no recent evidence of well-designed studies in support of sensory integration or kinesthetic training
- There was no significant difference in magnitude of effect size between traditional therapy and task-oriented or process-oriented approaches

• Authors of a systematic review of the literature published between 1984 and 2011 regarding the effectiveness of occupational therapy treatment intervention for children with DCD showed that CO-OP had the strongest evidence for improvements in occupational performance, but there remains a need for a stronger evidence base. Evidence regarding the use of sensory integration to improve occupational performance was limited[32]

- Nineteen articles met the criteria and were appraised using the Critical Appraisal Skills Programme, ranging from a 2 to 6 level of evidence. Meta-analysis was not completed since the authors varied greatly in their use of outcome measures

• Researchers in Israel conducted a study to see if relatively short-term direct physical therapy intervention could improve overall motor skill performance of children aged 6–12 years in whom DCD and ADHD were diagnosed, as measured by the MABC[9]

- The MABC evaluates manual dexterity, ball-handling skills, and static-dynamic balance. A total score of 5–15% indicates children are at risk for DCD. A total score of > 15% is considered normal motor performance
- Fifty percent of the children achieved normal scores on the MABC (> 15%)
- Thirty-five percent of the children improved their motor skills but still scored < 15% on the MABC after 4 weeks of physical therapy intervention vs. no improvement in the control group
  - Physical therapy intervention was 1 hour twice a week for 4 weeks and focused on cognitive task-specificactivities, motor learning principles, attention to skill performance, and self-control when performing activities

• Children with DCD who participated in a 9-week, 30 minute/treatment session intervention period were compared to a control group of children with DCD who did not receive NTT (mean age 7 years, 2 months for both groups) in a study conducted in the Netherlands[4]

- There was a statistically significant improvement in overall motor skill performance the intervention group vs. no change in the control group as measured with the MABC
- Using the Test of Gross Motor Development-2 (TGMD-2), the treatment group's gross motor skills increased vs. a decrease in the control group compared to their baseline scores
- Results indicate that motor performance does not improve spontaneously

• Researchers in the Netherlands conducted a pilot study to assess which NTT teaching principles had greater positive treatment effects in children with DCD[28]

- Providing clues on how to perform a task, asking children about a task, and explaining why a movement should be executed in a certain way were related to better movement performance, as indicated by statistically significant improvements on pretest and posttest scores using the MABC and the TGMD-2

• A generalized strength training program for children with DCD can be beneficial for improving body awareness, proprioception, and gross motor skills[19]

- Children with DCD generate less maximum force and power compared to typically developing peers
- Decreased strength and power may be underlying deficits that contribute to motor difficulties in these children
- Researchers in the United States conducted a case study of a 5-year-old boy with DCD who underwent a strength training program over 12 weeks[19]
  - Ten exercises (5 LE, 3 UE, 1 trunk extensor, and 1 abdominal) were instructed which he performed in 1 set of 6 reps with 30–120 seconds of rest between exercise sets, 2 x week with a 5-minute warm-up and cool-down
  - Most substantial improvements were increased gluteus medius, gluteus maximus, and rectus abdominis strength as measured by handheld dynamometer

- Increased subtest scores on the BOT: strength, running speed, and agility, with minimal gains in the other 3 subtests

• Difficulty with postural control/balance is one of the most common features in children with DCD[5,6,8]
  – Children with DCD typically present with increased amounts of postural sway in either single- or double-limb quiet stance, indicating a less efficient and more immature postural control strategy
  – Research studies are inconsistent with regard to the degree to which vision plays a role in maintaining postural stability in children with DCD
    - Taiwanese researchers compared postural sway profiles and balance of children with DCD aged 9–10 years to age-matched peers without DCD[5]
      - Children with DCD demonstrated greater difficulty standing on nondominant leg with eyes open and eyes closed and did not rely on visual feedback in the same manner as children without DCD
      - Researchers concluded that children with DCD are less able to recognize when they approach their balance threshold and/or are less capable of correcting their posture; they may be behind their typical peers in acquiring the skills of integrating vestibular and proprioceptive information
    - Belgian researchers compared postural control during bilateral stance in 10 boys (aged 6–8 years) with DCD in 4 sensory conditions (with or without vision, firm or variable surface) using a computerized posturography system[8]
      - In all 4 settings, mean postural sway velocity was greater despite a normal score on the balance items of the MABC; however, the MABC balance score only represents the ability to maintain balance without considering the amount of postural sway or strategy being used
      - Postural control difficulties may be associated with decreased sensorimotor proficiency, the inability to re-weight sensory information in response to environmental demands
      - Results also indicated a greater dependence on vision in the boys with DCD when standing on a firm surface but not in the other 3 settings
  – Researchers in China conducted a randomized controlled study on the effects of 3 months of taekwondo (TKD) training on the sensory organization and standing balance of children with DCD[38]
    - Three months of daily TKD training can improve sensory organization and standing balance for children with DCD
      - Twenty-one children were randomly assigned to undergo daily TKD training for 3 months (1 hour/day); 23 children with DCD and 18 typically developing children received no training as the control group
      - Sensory organization and standing balance were evaluated using a sensory organization test and unilateral stance test, respectively
      - Post-hoc analysis demonstrated that improvements in the vestibular ratio and unilateral stance test sway velocity were significantly greater in the TKD group than in the control group
      - Significant improvements in visual ratios, vestibular ratios, sensory organization test composite scores, and unilateral sway test sway velocities were also observed in the TKD group after training

• Wiibalance board can be used as an adjunct to traditional balance and postural stability training interventions
  – Researchers in the Netherlands conducted an RCT to assess the effects of using the Wiibalance board on children with poor motor performance[46]
    - Twenty-nine children (7 to 12 years of age) with poor motor performance (score below the 16% percentile in the motor ability and balance skills section on the MABC-2) were randomly assigned to either the control group or the Wii group
    - Children in the Wii group participated in a 6-weektreatment session
    - Children in the Wii group significantly improved their total balance scores on the MABC-2 and the BOT-2 following the 6-week treatment intervention compared to no significant progress in the control group
  – Please see *Clinical Review…Nintendo Wii Fit Balance and Rehabilitation in Children and Adolescents*; Topic ID Number: T709223 for details on the use of these gaming devices for balance and postural stability rehabilitation

• Authors of an RCT study compared the effectiveness of functional movement-power training (FMPT) and functional moving training (FMT) on improving balance in patients with DCD and suggest that FMPT can enhance balance and improve neuromuscular performance[54]
  – Based on a 2016 study in Hong Kong with 161 children with DCD (age 6–10 years)
  – Children were randomized into three groups: FMPT, FMT, and control group (no intervention). The FMPT and FTM group performed their respective intervention twice a week for 3 months
  – Those in the FMT group performed task-specific training while using electromyographic biofeedback to assist with motor learning difficulties, improve neuroplasticity, and improve balance
  – The FMPT performed the same tasks as the FMT group, but also performed power resistance training exercises

- Authors of a 2017 systematic review of randomized control trials (N = 846 articles) suggested that neuromotor task training, task-orientedmotor training, and motor imagery + task practice training are considered the most effective interventions to improve motor skills in children with DCD[57]

Problem	Goal	Intervention	Expected Progression	Home Program

Decreased balance/ postural control (static and dynamic) for single-limb stance (SLS) and/or double-limb stance (DLS)	Increase static and dynamic balance necessary for age-appropriate, safe, independent functional skills such as standing in line at school, donning/doffing shoes and socks and clothing while standing Improve postural control for age-appropriate levels necessary to safely participate in physical activities such as riding a bicycle without training wheels, throwing and catching various size balls, kicking a stationary and moving ball	**Therapeutic exercises and/or activities** (1,7,8,19,21,28) Develop a comprehensive balance training/postural stability program for the patient based on his/her impairments. This may include the following skills: SLS and DLS with eyes open and eyes closed, static and dynamic surfaces with SLS and DLS activities (i.e., Bosu ball, ½ foam roll, wobble board), balance beam, hurdles Therapists should consistently motivate and encourage the patient while providing specific instructions and feedback; motor learning is enhanced by providing adequate knowledge of performance Provide necessary physical assistance for the patient to safely and confidently attempt and perform the activity Perform task-specific functional activities that require SLS, such as donning/doffing socks in a standing position, throwing a ball like a baseball pitcher SI and processing treatment may be an alternative approach to address proprioceptive deficits. Common treatment interventions incorporate weighted	The intensity and duration of exercises should be gradually progressed as patient demonstrates improved postural stability and independent skill acquisition Increase the level of difficulty of the task from simple to complex as the patient demonstrates independence with the desired skill (i.e., DLS to SLS, eyes open vs. eyes closed, reaching in one plane of motion vs. multiple planes, stable surface vs. dynamic surface)	Instruct patient and/ or primary caregiver with an individualized therapeutic home program This should be performed every other day per therapist specific recommendations with appropriate supervision Patient and/or primary caregiver must demonstrate independence when performing home program

Decreased functional strength of UE, LE, and/core musculature	Increase functional strength in order to perform age-appropriate gross and/or fine motor skills as well as age-appropriate sport-specific skills successfully May use other strength measures to assist with goal measurement, such as a handheld dynamometer or MMT as indicated	**Therapeutic exercises** (6,19) According to the American College of Sports Medicine, strength training in children with proper supervision and guidance by a trained professional is safe Develop individualized strength program for UE, LE, and core musculature as indicated, utilizing eccentric and concentric activities within full available ROM Determine initial load for each exercise by the child's ability to lift a weight through the full ROM for at least 6 reps without deterioration of the performance Single joint exercises vs. multijoint exercises may be easier to perform Large muscle group exercises should be performed prior to small group exercises; multijoint exercises prior to single-joint exercises; alternate strengthening agonist and antagonist muscle groups Free weights and cuff weights may be used to facilitate muscle contractions similar to performing everyday tasks	The intensity and duration of exercises should be gradually progressed as patient increases flexibility and strength Exercises should be modified to patient's abilities (e.g., increase number of repetitions and/sets, increase resistance) Generally, use higher repetitions with only moderate loads to increase muscle strength and endurance in children Perform 1–3 sets of 6–15 reps Rest intervals of 30–120 seconds between sets	Instruct patient and/or primary caregiver with an individualized therapeutic home program This should be performed every other day per therapist specific recommendations with appropriate supervision Patient and/or primary caregiver must demonstrate independence when performing home program

Gross motor skills delay Significantly delayed gross motor skill coordination for age-appropriate leisure activities such as team sports or PE/ playground games	Maximize patient's functional independence for age-appropriate gross motor skills Utilize one or more outcome measure assessment tools as appropriate (see *Outcome measures*, below)	**Functional training/ therapeutic exercises** (4,21,28) Research indicates that during the early phases of learning, children benefit from skill demonstration and advance towards more verbal instructions in the later phases of skill development Critical to motor learning are the following: Emphasize demonstrating the task that is to be performed Provide clear, concise verbal instructions on what the skill is and how to perform it Verbal instructions should stress ways in which children can recognize their own errors Utilize knowledge of performance and knowledge of results in order to enhance motor learning NTT – Example of throwing(21,28) First instruct the child in the basic biomechanics involved in throwing a ball overhand Practice basic throwing	Progress each patient on an individualized basis with the goal of maximizing functional mobility and independence Utilize the principles of motor learning and NTT as indicated to facilitate skill acquisition The ultimate goal is to have a child successfully perform a desired skill, such as throwing, automatically, on a continuum from basic to more complex with attention demanding situations	Provide patient and family/caregivers with written instructions regarding functional activities that can be performed at home and correct use and/ or application of equipment

Decreased cardiorespiratory fitness	Increase functional capacity/ cardiorespiratory endurance and improve overall quality of life Utilize one or more outcome measure assessment tools as appropriate (see *Outcome measures*, below)	**Aerobic and conditioning program** (3,6,7) Incorporate age-appropriate aerobic endurance activities such as shuttle run drills, obstacle course, tag, kick-the-can, jumping jacks, etc., in conjunction with 6-min. walk, stationary bike, cycle ergometer, or treadmill Properly monitor patient's HR and/or level of perceived exertion as needed (See *Treatment summary*, above, for more details)	Gradual progression of intensity and duration of aerobic conditioning program exercises is patient specific May initially start with at least 10 minutes of aerobic activity at 50% age-predicted HRmax (220-age) and progress to at least 30 minutes of continuous exercise at ≥ 70% HRmax Provide necessary rest breaks	Provide patient and family/ caregivers with written instructions regarding aerobic exercise that can be performed at home
Poor body mechanics/ ergonomics with basic activities such as carrying heavy objects (backpack) and improper sitting posture	Independently demonstrate proper body mechanics/ ergonomics for basic activities such as lifting and carrying heavy objects as well as sitting posture	**Comprehensive postural education program provided by the clinician** (7) Therapist verbally and actively demonstrates proper body mechanics for sitting posture and lifting and carrying heavy objects Provide patient with adequate verbal feedback/knowledge of performance	Patient and/or primary caregivers should be able to independently demonstrate proper ergonomic techniques (e.g., lifting and carrying heavy objects, sitting posture for studying at home and school) without the need for verbal cues	Provide the patient and/ primary caregivers with thorough instructions and pictures demonstrating proper body mechanics These techniques should be incorporated into the patient's daily routine for optimal benefit

Desired Outcomes/Outcome Measures

› Improved functional mobility, cardiorespiratory endurance, LE/UE functional strength, and overall quality of life
- BMI – physical fitness/body composition
- PBS – balance assessment
- 6MWT – cardiovascular fitness
- PEDI – functional status questionnaire
- Sensory Profile Survey – sensory integration parent questionnaire

› Improved age-appropriate motor skills
  • PEGS – child-assisted goal assessment for gross and fine motor skills
  • MABC or MABC-2– gross and fine motor assessment
  • BOT or BOT-2– gross and fine motor assessment, balance subscale
  • PDSM-2 – gross and fine motor assessment
  • DCDQ – developmental coordination questionnaire
› Increased daily physical activity
  • Activity log
› Decreased patient and/or primary caregiver distress and anxiety
  • VABS-II: parent questionnaire to measure adaptive behavior

Maintenance or Prevention

› Therapists need to educate primary caregivers, teachers, and parents about DCD so that children with DCD can receive therapeutic intervention to ameliorate difficulties that can arise in the school setting[1,31]
  • ELBW/extremely premature children should be assessed at 3 years of age in order to identify those who may have DCD[5]
  • The predictive value for diagnosing DCD using the PDSM-2 Fine Motor Subscales increases with age from 3 and 8 years old. Adequate predictive value for DCD at 3 years of age allows for earlier intervention[5]
  • Early intervention is more likely to improve coordination and motor skills in children with DCD, which will have a positive effect on their self-esteem and socialization[1,5]
› Parents have a key role in advocating for early identification and better services for treatment intervention in the clinic and school environment[31]
› Clinicians need to develop educational outreach programs and other innovative practices designed to increase physicians' ability to accurately identify DCD[31]
  • Numerous booklets and pamphlets can be accessed on the CanChild website (see below) to increase awareness of DCD
› Actively encourage participation in appropriate leisure activities that emphasize physical fitness and motor skills that the child can perform successfully in order to maintain muscle strength, power, and endurance while promoting a positive social and psychosocial environment
  • Physical activity is linked with peer acceptance in childhood and adolescence, which affects self-esteem and ability to make friends[40,41]
  • Finding physical activities that a child is interested in and can be successful at will promote a healthier lifestyle and decrease their risk of obesity and cardiovascular disease[3,24,25,26]
  • Children with DCD are at increased risk for developing obesity and cardiovascular disease based on decreased strength, decreased cardiovascular fitness, and increased BMI[35]
  • TKD training may be recommended as a therapeutic leisure activity that can promote self-esteem, balance, strength, postural control, and peer relationships
› When making recommendations regarding participating in sporting and leisure activities, it is important to keep in mind the type of tasks necessary for the sport and activity as well as the degree of teaching involved
  • Activities that require a sequence of movements that are very repetitive, such as swimming, running, skating, skiing, and bicycling, provide a greater chance for the child's success. Furthermore, these activities can be performed alone. Non-competitive team sports are often more appealing to an individual with DCD and the child can continue to participate in these activities as he or she enters adolescence and adulthood
    – Researchers have postulated that many children with DCD are relatively unmotivated to engage in competitive team sports, as they are aware that their physical abilities are not as good as those of their peers[35]
  • In a 2011 Australian study, children with DCD were more likely to participate in moderate to vigorous physical activity if their primary caregiver did. Furthermore, when parents perceived their child's motor abilities as inferior, children with DCD were less likely to participate in moderate to vigorous physical activity than when parents had a more positive outlook. This is important to discuss with the primary caregivers when establishing a home program[35]
  • These activities may be quite challenging during the early learning period because all novel skills are difficult for children with DCD and it is difficult for them to generalize easily from previous learning[3]

- Increased encouragement, individualized attention, and an unintimidating environment will increase the odds of success for the child[26]
- Activities that require a high degree of spatial and temporal variability, such as hockey, soccer, baseball, football, basketball, and other ball-related sports, can be extremely difficult for children with DCD. These sports involve a high level of unpredictability, and when the environment is changing or variable the child must not only learn the movement patterns/skills but continuously monitor the environment and adapt to change in order to be successful[3,26]

Patient Education

› General information regarding DCD and dyspraxia, http://www.dystalk.com/talks/56-what-is-dyspraxia-dcd
› European Academy of Childhood Disability Guidelines for diagnosis and treatment of DCD,https://www.eacd.org/publications.php
› CanChild, https://www.canchild.ca/
› National Health Service (NHS) England. Developmental co-ordination disorder (dyspraxia) in children–Diagnosis. NHS Choices website, http://www.nhs.uk/conditions/dyspraxia-(childhood)/pages/diagnosis.aspx

Coding Matrix

References are rated using the following codes, listed in order of strength:

M	Published meta-analysis	**RV**	Published review of the literature	**PP**	Policies, procedures, protocols
SR	Published systematic or integrative literature review	**RU**	Published research utilization report	**X**	Practice exemplars, stories, opinions
RCT	Published research (randomized controlled trial)	**QI**	Published quality improvement report	**GI**	General or background information/texts/reports
R	Published research (not randomized controlled trial)	**L**	Legislation	**U**	Unpublished research, reviews, poster presentations or other such materials
C	Case histories, case studies	**PGR**	Published government report		
G	Published guidelines	**PFR**	Published funded report	**CP**	Conference proceedings, abstracts, presentation

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