

14 - 31.8a Developmental Coordination Disorder

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Hedges JH, Adolph KE, Amso D, Bavelier D, Fiez J, Krubitzer L, McAuley JD, Newcombe NS, Fitzpatrick SM, Ghajar J. Play, attention, and learning: How do play and timing shape the development of attention and influence classroom learning? *Ann N Y Acad Sci.* 2013;1292:1-20.

Jura MB, Humphrey LH. Neuropsychological and cognitive assessment of children. In: Sadock BJ, Sadock VA, eds. *Kaplan & Sadock's Comprehensive Textbook of Psychiatry.* 9th ed. Vol. 2. Philadelphia: Lippincott Williams & Wilkins; 2005;895.

Lewis C, Hitch GJ, Peter W. The prevalence of specific arithmetic difficulties and specific reading difficulties in 9- to 10-year-old boys and girls. *J Child Psychol Psychiatry.* 1994;35:283-292.

Meeks J, Adler A, Kunert K, Floyd L. Individual psychotherapy of the learning-disabled adolescent. In: Flaherty LT, ed. *Adolescent Psychiatry: Developmental and Clinical Studies.* Vol. 28. Hillsdale, NJ: Analytic Press; 2004:231.

Plomin R, Kovas Y. Generalist genes and learning disabilities. *Psychol Bull.* 2005;131:592.

Tannock R. Reading disorder. In: Sadock BJ, Sadock VA, eds. *Kaplan & Sadock's Comprehensive Textbook of Psychiatry.* 9th ed. Vol. 2. Philadelphia: Lippincott Williams & Wilkins; 2005:3107.

Tannock R. Mathematics disorder. In: Sadock BJ, Sadock VA, eds. *Kaplan & Sadock's Comprehensive Textbook of Psychiatry.* 8th ed. Vol. 2. Philadelphia: Lippincott Williams & Wilkins; 2005:3116.

Tannock R. Disorder of written expression and learning disorder not otherwise specified. In: Sadock BJ, Sadock VA, eds. *Kaplan & Sadock's Comprehensive Textbook of Psychiatry.* 8th ed. Vol. 2. Philadelphia: Lippincott Williams & Wilkins; 2005:3123.

Vadasy PF, Sanders EA, Peyton JA. Relative effectiveness of reading practice or word-level instruction in supplemental tutoring: how text matters. *J Learn Disabil.* 2005;38:364.

31.8 Motor Disorders

31.8a Developmental Coordination Disorder

Developmental coordination disorder is a neurodevelopmental disorder in which a child's fine and/or gross motor coordination is slower, less accurate, and more variable than in peers of the same age. Affecting about 5 to 6 percent of school-age children, 50 percent of children with developmental coordination disorder also have comorbid attention-deficit/hyperactivity disorder (ADHD) or dyslexia. A meta-analysis of recent research on developmental coordination disorder concluded that three general areas of deficits contribute to the disorder: (1) Poor predictive control of motor movements; (2) deficits in rhythmic coordination and timing; and (3) deficits in executive functions, including working memory, inhibition, and attention. Children with developmental motor coordination

struggle to perform accurately the motor activities of daily life, such as jumping, hopping, running, or catching a ball. Children with coordination problems may also agonize to use utensils correctly, tie their shoelaces, or write. A child with developmental coordination disorder may exhibit delays in achieving motor milestones, such as sitting, crawling, and walking, because of clumsiness, and yet excel at verbal skills. Developmental coordination disorder, thus, may be characterized by either clumsy gross and/or fine motor skills, resulting in poor performance in sports and even in

academic achievement because of poor writing skills. A child with developmental coordination disorder may bump into things more often than siblings or drop things. In the 1930s, the term clumsy child syndrome began to be used in the literature to denote a condition of awkward motor behaviors that could not be correlated with any specific neurological disorder or damage. This term continues to be used to identify imprecise or delayed gross and fine motor behavior in children, resulting in subtle motor inabilities, but often significant social rejection. Gross and fine motor impairment in developmental coordination disorder cannot be explained on the basis of a medical condition, such as cerebral palsy, muscular dystrophy, or a neuromuscular disorder. Currently, certain indications are that perinatal problems, such as prematurity, low birth weight, and hypoxia may contribute to the emergence of developmental coordination disorders. Children with developmental coordination disorder are at higher risk for language and learning disorders. A strong association is seen between speech and language problems and coordination problems, as well as an association of coordination difficulties with hyperactivity, impulsivity, and poor attention span. Children with developmental coordination disorder may resemble younger children because of their inability to master motor activities typical for their age group. For example, children with developmental coordination disorder in elementary school may not be adept at bicycle riding, skateboarding, running, skipping, or hopping. In the middle school years, children with this disorder may have trouble in team sports, such as soccer, baseball, or basketball. Fine motor skill manifestations of developmental coordination disorder typically include clumsiness using utensils and difficulty with buttons and zippers in the preschool age group. In older children, using scissors and more complex grooming skills, such as styling hair or putting on makeup, is difficult. Children with developmental coordination disorder are often ostracized by peers because of their poor skills in many sports, and they often have long-standing difficulties with peer relationships.

Developmental coordination disorder is categorized in the Fifth Edition of the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a Motor Disorder, along with stereotypic movement disorder and tic disorders. **EPIDEMIOLOGY** The prevalence of developmental coordination disorder has been estimated at about 5 to 6 percent of school-age children. The male-to-female ratio in referred populations tends to show increased rates of the disorder in males, but schools refer boys more often for testing and special education evaluations. Reports in the literature of the male-to-female ratio have ranged from 3 to 1 to as high as 7 to 1; however, the most current estimates are approximately 2 males for every one female.

COMORBIDITY Developmental coordination disorder is strongly associated with ADHD, specific learning disorder, particularly in reading, as well as language disorder. Children with

coordination difficulties have higher than expected rates of language disorder, and studies of children with language disorder report very high rates of "clumsiness." Developmental coordination disorder is also associated, but less strongly, with specific learning disorder with impairment in mathematics, and in written expression. A study of children with developmental coordination disorder reported that, although motor coordination is critical for accuracy in tasks that require

speed, poor motor coordination is not directly correlated with degree of inattention. Thus, in children comorbid for ADHD and developmental coordination disorder, children with the most severe ADHD do not necessarily have the worst developmental coordination disorder. Functional neuroimaging, pharmacological, and neuroanatomical studies suggest that motor coordination depends on the integration of sensory input and an action response, not purely through sensorimotor function and higher level thinking. Investigations of comorbid developmental coordination disorder and ADHD are trying to ascertain whether this comorbidity is due to overlapping genetic factors. Peer relationship problems are common among children with developmental coordination disorders, because of rejection that often occurs along with their poor performance in sports and games that require good motor skill. Adolescents with coordination problems often exhibit poor self-esteem and academic difficulties. Recent studies underscore the importance of attention to both victimization of children and adolescents with developmental motor coordination by peers and the potential resulting damage to self-worth. Children and adolescents with developmental coordination disorder who are bullied have higher rates of poor self-esteem that often deserves clinical attention.

ETIOLOGY The causes of developmental coordination disorder are believed to be multifactorial, and likely include both genetic and developmental factors. Risk factors postulated to contribute to this disorder include prematurity, hypoxia, perinatal malnutrition, and low birth weight. Prenatal exposure to alcohol, cocaine, and nicotine has also been hypothesized to contribute to both low birth weight and cognitive and behavioral abnormalities. Developmental coordination disorder rates of up to 50 percent have been reported in children born prematurely. Researchers have proposed that the cerebellum may be the neurological substrate for comorbid cases of developmental coordination disorder and ADHD. Neurochemical abnormalities and parietal lobe lesions have also been suggested to contribute to coordination deficits. Studies of postural control, that is, the ability to regain balance after being in motion, indicate that children with developmental coordination disorder who have adequate balance when standing still, are unable to accurately correct for movement, resulting in impaired balance, compared with other children. A study concluded that, in children with developmental coordination disorder, neural signals from the brain to particular muscles involved in balance, are neither being optimally sent or received. These findings have also implicated the cerebellum as a potential anatomical site for the dysfunction of

developmental coordination disorder. Two mechanisms of developmental coordination disorder have been hypothesized for the disabilities of the disorder. The first one, called the automatization deficit hypothesis, suggests that, similar to dyslexia, children with developmental coordination disorder have difficulty developing automatic motor skills. The second hypothesis, the internal modeling deficit hypothesis, suggests that children with developmental coordination disorder are unable to perform the typical internal cognitive models that predict the sensory consequences of motor commands. In both scenarios, the cerebellum is believed to play an important role in motor coordination and in developmental coordination disorder.

DIAGNOSIS The diagnosis of developmental coordination disorder depends on poor performance in activities requiring coordination for a child's age and intellectual level. Diagnosis is based on a history of the child's delay in achieving early motor milestones, as well as on direct observation of current deficits in coordination. An informal screen for developmental coordination disorder involves asking the child to perform tasks involving gross motor coordination (e.g., hopping, jumping, and standing on one foot); fine motor coordination (e.g., finger-tapping and shoelace tying); and hand-eye coordination (e.g., catching a ball and copying letters). Judgments regarding poor performance must be based

on what is expected for a child's age. A child who is mildly clumsy, but whose functioning is not impaired, does not qualify for a diagnosis of developmental coordination disorder. The diagnosis may be associated with below-normal scores on performance subtests of standardized intelligence tests and by normal or above-normal scores on verbal subtests. Specialized tests of motor coordination can be useful, such as the Bender Visual Motor Gestalt Test, the Frostig Movement Skills Test Battery, and the Bruininks-Oseretsky Test of Motor Development. The child's chronological age must be taken into account, and the disorder cannot be caused by a neurological or neuromuscular condition. Examination, however, may occasionally reveal slight reflex abnormalities and other soft neurological signs.

CLINICAL FEATURES The clinical signs suggesting the existence of developmental coordination disorder are evident as early as infancy in some cases, when a child begins to attempt tasks requiring motor coordination. The essential clinical feature is significantly impaired performance in motor coordination. The difficulties in motor coordination may vary with a child's age and developmental stage (Table 31.8a-1).

Table 31.8a-1
Manifestations of Developmental Coordination Disorder

In infancy and early childhood the disorder may be manifested by delays in developmental motor milestones, such as turning over, crawling, sitting, standing, walking, buttoning shirts, and zipping up pants. Between the ages of 2 and 4 years, clumsiness appears in almost all activities requiring motor coordination. Affected children cannot hold objects and drop them easily, their gait may be unsteady, they often trip over their own feet, and they may bump into other children while attempting to go around them. Older children may display impaired motor coordination in table games, such as putting together puzzles or building blocks, and in any type of ball game. Although no specific features are pathognomonic of developmental coordination disorder, developmental milestones are frequently delayed. Many children with the disorder also have speech and language difficulties. Older children may have secondary problems, including academic difficulties, as well as poor peer relationships based on social rejection. It has been reported widely that children with motor coordination problems are more likely to have problems understanding subtle social cues and are often rejected by peers. A recent study indicated that children with motor difficulties were found to perform more poorly on scales that measure recognition of static and changing facial expressions of emotion. This finding is likely to be correlated to the clinical observations that children with motor coordination have difficulties in social behavior and peer relationships. Billy was brought for evaluation of suicidal ideation at 8 years of age, after complaining to his parents that he was being bullied by peers for being "bad" in

sports, and that nobody liked him. He only had one friend who also laughed at him sometimes, because he always dropped the ball and he looked "funny" while running. He was so upset about being rejected by peers when he tried to play sports that he refused to go to physical education class. Instead, he voluntarily went to the school counselor's office and stayed there until the period was over. Billy was already irritated because he had been diagnosed with ADHD and was on medication, and on top of that, he had difficulty with reading. Billy became so distraught that one day he told his school counselor that he wanted to kill himself. A developmental history revealed that he had been delayed for sitting, which he finally did at 10 months of age, and he could not walk without falling over until 30 months of age. Billy's parents were aware that he was very clumsy, but they believed that he would outgrow that. Even at 8 years of age, Billy's parents reported that, during meals, Billy often spilled his drinks and was quite awkward when he used a fork. Some of his food typically fell off of his fork or spoon before it reached his mouth, and he had great difficulty

using a knife and a fork. A comprehensive assessment of fine and gross motor skills demonstrated the following: Billy was able to hop, but he could not skip without briefly stopping after each step. Billy could stand with both feet together, but was unable to stand on tiptoe. Although Billy could catch a ball, he held a ball bounced to himself at chest level, and was unable to catch a ball bounced to him on the ground from a distance of 15 feet. Billy's agility and coordination were measured with the Bruininks-Oseretsky Test of Motor Development, which revealed functioning levels commensurate with those of an average 6-year-old child. Billy was referred to a neurologist for a comprehensive evaluation, because he appeared to be generally weak, and his muscles seemed floppy. Neurological evaluation was negative for diagnosable neurological disorders, and his muscle strength was actually found to be normal, despite his appearance. Based on the negative neurological examination and the finding of the Bruininks-Oseretsky Test of Motor Development, Billy was given a diagnosis of developmental coordination disorder. Billy's symptoms included mild hypotonia and fine motor clumsiness. After the diagnosis of developmental motor coordination was made, in addition to his already diagnosed ADHD and reading disorder, his treatment plan included private sessions with an occupational therapist who used perceptual-motor exercises to improve Billy's fine motor skills, targeting particularly writing and use of utensils. A written request was made for an Individualized Educational Plan (IEP) evaluation from the school with a goal of obtaining an adaptive physical education program. In addition, the request for a reading tutor, and a seat close to the front of the classroom were recommended to maximize his attention. Billy was enrolled in a treatment program using motor imagery training to reduce his clumsiness and improve coordination. Billy was relieved to be receiving help, especially for his reading and for sports activities, and no longer felt suicidal. Over a period of 3 months of treatment, Billy showed a noticeable improvement in his reading. His mood improved further,

especially because he was receiving praise from his teachers and parents. Billy's classmates were not picking on him the way they used to. As Billy began to feel better about himself, he began to play sports informally with his peers, although not competitively. Billy was granted an adaptive physical education program in school, and he was not required to play on teams. Instead, he practiced throwing and catching a ball and playing basketball with a staff member. Billy continued to show some degree of clumsiness, especially in his fine motor skills over the next few years, yet he was cooperative, with the occupational therapy interventions, his mood was bright, and he demonstrated continual improvement. (Courtesy of Caroly Pataki, M.D. and Sarah Spence, M.D.)

DIFFERENTIAL DIAGNOSIS The differential diagnosis includes medical conditions that produce coordination difficulties (e.g., cerebral palsy and muscular dystrophy). In autism spectrum disorder and intellectual disability, coordination usually does not stand out as a significant deficit compared with other skills. Children with neuromuscular disorders may exhibit more global muscle impairment rather than clumsiness and delayed motor milestones. Neurological examination and workup usually reveal more extensive deficits in neurological conditions than in developmental coordination disorder. Extremely hyperactive and impulsive children may be physically careless because of their high levels of motor activity. Clumsy gross and fine motor behavior and ADHD as well as reading difficulties are highly associated. **COURSE AND PROGNOSIS** Historically, it was believed that developmental coordination spontaneously improved over time; however, longitudinal studies have shown that motor coordination problems can persist into adolescence and adulthood. When mild to moderate clumsiness is persistent, some children can compensate by developing interests in other skills. Some studies suggest a more favorable outcome for children who have average or aboveaverage intellectual capacity, in that they come up with strategies to

develop friendships that do not depend on physical activities. Clumsiness typically persists into adolescence and adult life. One study following a group of children with developmental coordination problems over a decade found that the clumsy children remained less dexterous, showed poor balance, and continued to be physically awkward. The affected children were also more likely to have both academic problems and poor self-esteem. Children with developmental coordination disorder have also been shown to be at higher risk for obesity, have difficulties with running, and are at greater risk of future cardiovascular diseases. TREATMENT

Interventions for children with developmental coordination disorder utilize multiple modalities, including visual, auditory, and tactile materials targeting perceptual motor training for specific motor tasks. Two broad categories of interventions are the following: (1) deficit-oriented approaches, including sensory integration therapy, sensorimotor-oriented treatment, and process-oriented treatment; and (2) task-specific interventions, including neuromotor task training and cognitive orientation to daily occupational performance (CO-OP). More recently, motor imagery training has been incorporated into treatment. These approaches involve visual imagery exercises using CD-ROM; they have a broad range of foci, including predictive timing for motor tasks, relaxation and mental preparation, visual modeling of fundamental motor skills, and mental rehearsal of various tasks. This type of intervention is based on the notion that improved internal representation of a movement task will improve a child's actual motor behavior. The treatment of developmental coordination disorder generally includes versions of sensory integration programs and modified physical education. Sensory integration programs, usually administered by occupational therapists, consist of physical activities that increase awareness of motor and sensory function. For example, a child who bumps into objects often might be given the task of trying to balance on a scooter, under supervision, to improve balance and body awareness. Children who have difficulty writing letters are often given tasks to increase awareness of hand movements. Schoolbased occupational therapies for motor coordination problems in writing include utilizing mechanisms that provide resistance or vibration during writing exercises, to improve grip, and practicing vertical writing on a chalk board to increase arm strength and stability while writing. These programs have been shown to improve legibility of student's writing, but not necessarily speed, because students learn to write with greater accuracy and deliberate letter formation. Currently, many schools also allow and may even encourage children with coordination difficulties that affect writing to use computers to aid in writing reports and long papers. Adaptive physical education programs are designed to help children enjoy exercise and physical activities without the pressures of team sports. These programs generally incorporate certain sports actions, such as kicking a soccer ball or throwing a basketball. Children with coordination disorder may also benefit from social skills groups and other prosocial interventions. The Montessori technique may promote motor skill development, especially with preschool children, because this educational program emphasizes the development of motor skills. Small studies have suggested that exercise in rhythmic coordination, practicing motor movements, and learning to use word processing keyboards may be beneficial. Parental counseling may help reduce parents' anxiety and guilt about their child's impairment, increase their awareness, and facilitate their confidence to cope with the child. An investigation of children with developmental coordination disorder showed positive results using a computer game designed to improve ability to catch a ball. These children were able to improve their game score by practicing virtual catching without specific instructions on how to utilize the visual cues. This has implications for

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