

Developmental Coordination Disorder

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Overview

Background

Movement clumsiness has gained increasing recognition as an important condition of childhood; however, its diagnosis is uncertain. Approaches to assessment and treatment vary depending on theoretical assumptions about etiology and its developmental course.

Over the past century, many terms have been used to describe children with clumsy motor behavior. The wide variation in labeling has depended to a large extent on cultural or professional backgrounds. For example, medical professionals use medical terms (eg, clumsy child syndrome or minimal brain dysfunction), whereas educational professionals use educational terms (eg, poorly coordinated children, movement-skill problems, or physical awkwardness).

In addition, the various labels used have embodied assumptions about the etiology. Examples include developmental dyspraxia (which suggests underlying difficulties in motor planning), perceptual motor difficulties (which suggests problems in perceptual motor integration), minor neurologic dysfunction (MND), and sensory integrative dysfunction.

In response to the confusing and counterproductive heterogeneity of the labels, participants at an international multidisciplinary consensus meeting in 1994 agreed to use the term developmental coordination disorder (DCD), as described in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV).[1] In 2013, the diagnostic criteria were further refined with the publication of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5).[2]

The currently available data are insufficient to permit clear definition of the parameters of motor coordination difficulties in children. Various grades of severity and comorbidity seem to exist. Some children have only a relatively minor form of motor dyscoordination, whereas others have associated learning disabilities, attention deficit, and other difficulties.

In 1996, Fox and Lent reported that in contrast to the common belief that children grow out of motor coordination difficulties, such difficulties in fact tend to linger if no intervention takes place.[3] Intervention can be beneficial if initiated during the first years of life, while the brain is changing dramatically and new connections and abilities are being acquired.

Children with multiple conditions are at greatest risk for developing behavioral difficulties over time. Some evidence supports dividing DCD into subtypes on the basis of main features, such as ability to manipulate objects, speed of movement, ability to catch objects (eg, balls thrown, struck, or kicked during sports activities), or writing ability.

A discussion about including DCD, as currently defined, into the cerebral palsy category was held.[4] This inclusion would put DCD on the low end of the continuum of neuromotor disabilities, also described as minimal cerebral palsy, and result in a 20-fold increased incidence.[5]

Diagnostic criteria (DSM-5)

DSM-5 classifies DCD as a discrete motor disorder under the broader heading of neurodevelopmental disorders.[2] The specific DSM-5 criteria for DCD are as follows:

- Acquisition and execution of coordinated motor skills are below what would be expected at a given chronologic age and opportunity for skill learning and use; difficulties are manifested as clumsiness (eg, dropping or bumping into objects) and as slowness and inaccuracy of performance of motor skills (eg, catching an object, using scissors, handwriting, riding a bike, or participating in sports)
- The motor skills deficit significantly or persistently interferes with activities of daily living appropriate to the chronologic age (eg, self-care and self-maintenance) and impacts academic/school productivity, prevocational and vocational activities, leisure, and play
- The onset of symptoms is in the early developmental period
- The motor skills deficits cannot be better explained by intellectual disability or visual impairment and are not attributable to a neurologic condition affecting movement (eg, cerebral palsy, muscular dystrophy, or a degenerative disorder)



Pathophysiology

Motor coordination is the product of a complex set of cognitive and physical processes that are often taken for granted in children who are developing normally. Smooth, targeted, and accurate movements, both gross and fine, require the harmonious functioning of sensory input, central processing of this information in the brain, and coordination with the high executive cerebral functions (eg, volition, motivation, and motor planning of an activity). Also required is the performance of a certain motor pattern.

All of these elements must work in a coordinated and rapid way to enable complex movements involving different parts of the body. At present, our understanding of motor development in humans and the pathophysiology of motor clumsiness is still in its infancy. Because of the heterogeneity in the presentation and definition of developmental coordination disorder (DCD), finding its cause has been difficult. A variety of theoretical models explain the role of the nervous system in motor development.

In the traditional primitive reflex model (neuromaturational theory), higher centers exert increasing control over lower reflexes. In the dynamic systems model, the central nervous system (CNS) interprets sensory feedback, and the appropriate movement strategy is selected on the basis of current experience, the state of the internal and external environment, and one's memory of similar movements.

The neuronal group–selection model combines aspects of the 2 aforementioned models. Functional groups of neurons exist on all levels of the CNS. These groups are determined by evolution, but their functional integrity depends on afferent information produced by movement and experience. In both cortical and subcortical structures, these neuronal groups serve as early repositories for motor behavior or the receipt of specific sensory information.

Motor development is described in 2 phases. The first phase of primary variability is characterized by crude and erratic motor activity that does not require sensory information for its initiation or guidance. These self-generated movements give rise to afferent (visual or kinesthetic) inputs that reinforce more specific synaptic connections in each group.

In the second phase of motor development, sensory and motor factors interact, resulting in specific and complex muscle contraction patterns that characterize coordinated, goal-directed movement. As increasing efficient movement patterns are practiced, appropriate synaptic circuits are reinforced and subsequently established.

Adequate realization of a motion or sequence of movements requires the convergence of numerous pathways, as well as a central system in charge of integrating the information. The motor cortex, the cerebellum, and the vestibular system (which provides input about directionality, gravity, and motion) are all part of this central mechanism.

Proprioceptive information (ie, where the body is in space and how the limbs and body parts are positioned), visual input (ie, where the body is in space and where it should go), and an adequate degree of alertness (ie, activation of the reticular formation to an optimal degree) all provide information to the CNS. If one of these systems is not functioning adequately, the resulting planned movement may not be satisfactory or smooth.

The discussion below addresses some building blocks of motor functioning that are important in understanding difficulties with motor skills, their maturation, and the evaluation of children who struggle with these challenges.

Muscular tone

Muscular tone refers to the basic and constant ongoing contraction or activity in the muscles. It can be understood as a baseline or background level. Tone may be normal, too low (hypotonia), or too high (hypertonia). For example, hypotonic babies lie in a frog-leg position and appear floppy. Hypotonic infants or young children have difficulty maintaining posture against gravity and prefer to sit, leaning against something, or they may prefer to lie on the floor.

Hypotonic preschool-aged children may sit in a fashion that appears lazy; rather than sitting upright, they mostly sit in a slouching manner, leaning on the chair or a table with their head over the top of the table, or they may lie down during activities as much as possible. Of course, this positioning can also be observed in older children and is often erroneously interpreted as a sign of lack of interest or even disrespect.

By contrast, hypertonic children appear somewhat stiff and do not move in a smooth and natural way. Their movements may resemble those of a puppet or robot, and they lack the ordinarily smooth nature of movement in small motor acts. Infants may prefer to stand rather than sit and may appear to have “advanced” motor skills for their age.

Basic muscle tone that is too low or too high is one of the components of impaired motor skills. Children must fight low muscular tone to carry out movements, expending energy to maintain postures and activities. Hypertonic children may make many mistakes because of the over-activation of the muscular units.

Many children with baseline high or low tone are ultimately diagnosed with cerebral palsy, a collective term for a group of disorders affecting motor tone, movement, and posture that cause activity limitations and are due to nonprogressive disturbances that occurred in the developing fetal or infant brain.[5]

Gross motor skills

The term “gross motor skills” refer to the ability of children to carry out activities that require large muscles or groups of muscles. Muscles or groups of muscles should act in a coordinated fashion to accomplish a movement or a series of movements. Examples of gross motor tasks are walking, running, throwing, jumping, standing on one leg, hopping, skipping, and swimming.

Posture is an important element to consider in the assessment of gross motor skills. Adequate posture may make all the difference in a child’s ability to execute a movement. This is particularly true for infants and young children. A 6-month-old infant may be able to reach for a toy if sitting but may be unable to organize this movement if the trunk is tilted in such a way that he or she must strain to maintain a vertical position.

Fine motor skills

Fine motor skills consist of movements of small muscles (eg, those of the hands, feet, tongue, lips, and face) that act in an organized and subtle fashion to accomplish more difficult and delicate tasks. Fine motor skills are the basis of coordination, which begins with transferring from hand to hand across the midline at about age 6 months.

Examples of fine motor activities are writing, sewing, drawing, putting a puzzle together, imitating subtle facial gestures, pronouncing words (which involves coordination of the soft palate, tongue, and lips), blowing bubbles, and whistling. Many children who have difficulties with their fine motor skills also find it difficult to articulate sounds or words.

Muscular strength

Muscular strength refers to the intensity of the voluntarily exerted muscle contraction that may be required to carry out an

activity. Some children who struggle with motor clumsiness appear weak and slender and may have inadequate strength in their movements. Other children, on the other end of the continuum, may appear strong and muscular. Muscle strength is related to underlying tone (eg, low-tone muscles are usually weak, and weak muscles usually demonstrate low tone).

Children with hypertonicity in the leg muscles, who tend to toe-walk, may develop a higher muscular mass in the leg muscles to maintain the tiptoe position. Children who are too strong often appear brusque in their movements. Instead of softly caressing someone on the face, they may involuntarily slap the person when they are attempting to show affection. Something similar may happen when hypertonic children try to give a hug: the recipients may feel as if they are being physically crushed rather than embraced.

In contrast, a youngster with diminished muscular strength appears floppy or scrawny with thin arms, forearms, and legs. These children may execute movements that other children take for granted only at great cost. Hypotonic children cannot apply much pressure in a handshake or much force when pushing against resistance and therefore feel weak. They also fatigue easily and are unable to carry out simple tasks. For example, they may write with only thin lines and barely visible traces, and the pencil may slip out of their hand too easily.

In some cases, however, hypotonicity can be associated with normal strength (as, for example, in children with benign hypotonia or normal variations of tone). Ataxic (clumsy or poorly coordinated) children can also appear weak because truncal control affects posture, whereas poor coordination in the limbs impairs fine and gross motor tasks.

Motor planning

Motor planning involves the ability to imagine a mental strategy for carrying out a movement or an action—for instance, how to get on top of a table, how to move from point A to point B and overcome some obstacle, how to execute a dance step, or how to learn to ride a bicycle. Performing these tasks requires some planning in the sequencing of movements, including how the body and limbs will coordinate, the amount of strength that will be required, and the necessary steps that will be needed to achieve a specific goal.

Most of the time, in unaffected children, this function is achieved intuitively and without conscious effort. When children have difficulties in motor planning, however, they must carry out more conscious processing in order to complete the task.

When motor planning is impaired, parents notice that the child may frequently fall from a chair or stool, or even from a standing position, fall because anything that distracts the child's attention can result in poor motor execution. The child seemingly lacks the intuitive ability to execute a complex movement. His or her movements may appear slow or poorly coordinated, or they may involve the use of odd strategies (eg, reaching for something that is out of reach without changing posture).

Motor planning involves a number of abilities, including the visual detection of motion and errors in movement, selection of responses, and self-corrective motions. Movements must be timed adequately, and attention and concentration are also necessary.

Sequencing and speed of movements

Sequencing and speed of movements involves the order in which movements should proceed to accomplish a desired goal. This order is mostly unconscious or intuitive. When children with DCD try to manage a complex motor act or imitate something that has been modeled, their ability to do a series of movements may be compromised.

These children often have problems with other activities that might require sequencing (eg, reading, writing their ideas, or even continuous speech). Multiple neuroanatomic structures are important for generating and then sustaining complex movements, including the motor cortices (primary, supplementary, and premotor), thalami, basal ganglia, cerebellum, sensory systems (visual, vestibular, and proprioceptive), and multiple others; defects in any of these systems can manifest as abnormal motor skills.

Children with difficulties in motor skills often perform movements slowly as a result of their difficulty in organizing and coordinating motion. They may rely on visual cues to perform the movement (eg, in handwriting) more than other children do. Their need to view the movement slows their performance.

Sensory integration

Sensory integration refers to the functioning of the brain (ie, how it manages input and produces output, including motor responses). In 1979, Jean Ayres proposed this theory that motor difficulties in children might be related to disordered sensory integration; since then, many authors, mostly in the field of occupational therapy but also in mental health, have developed this theory further.[6]

The central concept is that children may struggle to integrate sensory input (eg, visual, auditory, tactile, and proprioceptive cues) and develop aversions (eg, to being touched or to being exposed to new sounds). Also, children may become overstimulated in any of these sensory channels, and their behavior and motor performance deteriorate in circumstances of overstimulation.

Each child has a unique profile of responses to sensory stimuli. Children with motor difficulties often have problems in the integration of sensory input, which make them vulnerable to problems resulting from sensory stimulation. These children are often referred to as having “sensory integration disorder” or “sensory processing disorder.” Sensory integration problems are associated with DCD, however, and thus these may represent variations of the same disorder.[7]

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Etiology

Environmental, intrauterine, and genetic factors may all contribute to poor abilities in motor functioning. Comorbid conditions (eg, high levels of lead, anemia, and iron deficiency) should be ruled out.

Exposure to alcohol and drugs (eg, cocaine or methamphetamine) in utero increases the risk for motor coordination problems in the fetus. Alcohol has direct effects on the neurons of the embryo or fetus, and it has been suggested that cocaine and other stimulants may affect the contraction of arterial vessels in various areas, leading to microinfarctions (eg, in the brain of the fetus).

Another major risk factor is prematurity. The more premature the baby, the greater the potential disturbance of neuronal migration and connections, which can lead to difficulties with attention span, self-control, and self-inhibition, as well as motor coordination problems. Database reviews indicate that extremely premature infants are at significantly increased risk for developing developmental coordination disorder (DCD) in comparison with term infants.[8, 9] Evidence also suggests that prematurity (birth at < 37 weeks' gestation) may be a predisposing factor.[10]

Genetic influences may also contribute to motor coordination difficulties. For instance, 2 studies examining the heritability of DCD determined it to be 0.47-0.69 with both polygenetic and environmental factors contributing.[11, 12] Genome-wide analysis of children with DCD suggested several genes that might contribute to the condition, but for none of these was the contributory relationship statistical significant.[13]

In many instances, the factors mentioned above are absent; however, the child is nonetheless challenged in movements and needs special assistance to carry out everyday activities.

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Epidemiology

Frequency

According to studies in different countries, the prevalence of motor coordination disorders widely varies. In some studies, rates are higher than that seen in the United States. For instance, in the United Kingdom, as many as 10% of all children reportedly have motor coordination difficulties. A conservative estimate suggests that fewer than 5% of children have the disorder worldwide; an additional 10% of children may have a minor form of the problem.

In 1998, Kadesjo and Gillberg found that motor coordination disorder frequently coexisted with poor attention span and concentration and that it was comorbid in about 6.1% of children in a sample of 409 nonreferred children in Sweden. Both

disorders tended to remain stable, persisting on follow-up 8 months later. Boys were affected more frequently than girls.[14]

In a 1996 study in Singapore by Wright and Sugden, 1.4-4% of children aged 6-9 years who were randomly sampled had difficulties in motor coordination. This study included only children with impairment in motor skills that notably interfered in their functioning in everyday life.[15]

Age-, sex-, and race-related demographics

Disturbances in motor abilities are most evident during the school years, as children face challenges such as physical education, sports, and writing. In many cases, children with motor coordination disturbances present at an early age, and motor coordination disturbances may be detected in children younger than school age.

Boys are thought to be affected more frequently than girls, though this possibility has not been systematically studied in the United States. A population-based study from the United Kingdom looked at more than 7000 children aged 7-8 years, using more strict inclusion criteria, and reported a prevalence of 1.8% and a male-to-female ratio of 1.7:1.[10] No evidence indicates an increased or decreased frequency of the condition according to racial groups.

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Prognosis

In the absence of intervention, children with motor coordination disorder tend to have symptoms that persist through adolescence into adulthood. Multiple follow-up studies of children with a diagnosis of motor coordination disorder have demonstrated that children do not outgrow their motor difficulties.[16, 17, 18]

developmental coordination disorder (DCD) does not directly lead to mortality. Children who have motor challenges may be more likely to be involved in accidents, because of the associated clumsiness; however, this clumsiness has not been shown to increase mortality.

DSM-5 cites the following conditions as commonly occurring in conjunction with DCD:[2]

- Speech and language disorder
- Specific learning disorder (especially reading and writing)
- Problems of inattention, including attention deficit hyperactivity disorder (ADHD; the most frequent coexisting condition [~50% of DCD patients])
- Autism spectrum disorder
- Disruptive and emotional behavioral problems
- Joint hypermobility syndrome

Some children with DCD become demoralized, develop poor self-esteem, and withdraw from daily activities, including those involving motor tasks (eg, drawing or writing). They may develop a feeling of being different. In some cases, children who show withdrawal behaviors are mistakenly believed to be poorly motivated, lazy, or not willing to make the effort to do a good job. Pediatricians and other health professionals must be sensitive to the signs and symptoms of emotional withdrawal arising from a child's fear of failure and sense of hopelessness.

Children who have poor self-esteem and who accept the premise that they are lazy, incapable, or stupid require intervention from a mental health professional. Children who continue to have these feelings and do not receive help often show poor social functioning and compromised emotional development. One study specifically found that children with DCD have increased rates of learning disability in attention, social skills, reading, and spelling. Depending on their severity, these comorbidities may affect treatment options.[19]

Intelligence quotient (IQ) may also be affected. A German study reports that the general IQ score of children with DCD was 1 standard deviation below that of children in the comparison group.[20]

Patient Education

Children aged 6-7 years can be positively counseled to make modifications in school and in social situations to make the best of their limitations in motor tasks. Acknowledging these limitations and helping the children understand that this problem is not voluntary on their part and not due to lack of effort or intellectual skill is important. As with other chronic medical conditions, the patient can be helped to understand the nature of the condition, to live with it, and to participate in its treatment.

Legal issues

Because definitions of conditions such as developmental coordination disorder (DCD) are evolving, and data supporting treatment practices are lacking, legal battles may arise, particularly in the authorization, or payment for, treatment services. Having an Individualized Educational Plan (IEP) for children with DCD is important because this qualifies the child for services through the school district.

Controversy exists regarding how much accommodation should be implemented in school for a child with a motor coordination difficulty.

In a child who has severe problems writing, opinions regarding how school personnel should attempt to help differ. Some think that the child should be expected to practice extensively with the expectation that the handwriting will improve; others believe that the child should be allowed to use a word-processing keyboard exclusively. In some cases, a child with a writing problem dictates his or her thoughts to others and does not attempt to write.

These complicated decisions regarding the creation of the most responsible and effective school intervention for a given child can be decided only on a case-by-case basis after experienced professionals have performed individualized evaluations.

A controversial issue is whether adolescents with DCD should be able to obtain a license to drive a car. Adolescents are typically eager to learn to drive so that they can increase their mobility and expand their peer relationships. However, adolescents with DCD may have difficulties with right-left coordination, crossing the body midline, depth perception, or other abilities that compromise optimal driving ability.

No generalizations can be applied to this situation. A rational and responsible decision depends on an individual evaluation of the given adolescent's abilities or difficulties and on the degree of danger of the activity.

Presentation

History

The diagnosis of problems in motor skills and coordination relies on a careful history of functioning while the child is performing motor tasks, a history of development in the motor and sensory integration areas, and physical findings.

In May 2013, the Council on Children with Disabilities published guidance on the early identification and evaluation of motor delays in children, which include formal developmental screening of children for possible motor delays and variations in muscle tone at their 9-, 18-, 30-, and 48-month well-child visits.[1, 2]

The Council advises that pediatricians not only should watch how children perform requested tasks but also should pay close attention to general posture, play, and spontaneous motor functions. Muscle tone deficiencies may also indicate neuromotor delays from disorders such as cerebral palsy.

Children who find performing certain motor tasks difficult, frustrating, or even impossible often become discouraged and

subsequently avoid these tasks altogether. Statements such as “I hate to draw,” “I hate writing,” or “I hate sports” may be their way of disclosing their feeling of incompetence while attempting to save face. Eventual avoidance of challenging physical tasks in a child who works hard on drawing or writing with poor results is understandable. Children with developmental coordination disorder (DCD) often end up feeling angry, frustrated, or sad.

Because children may not volunteer that in addition to not liking specific activities or tasks, they feel inadequate in performing them, the true problem is often difficult for parents and clinicians to identify. When a child reports not enjoying most physical activities, careful observation may be required after the child is asked to perform a few motor tasks to demonstrate the degree of challenge these activities pose to the child.

When the condition is serious and noticeable to everyone, the child is most likely to be stigmatized at school and often at home. Children with motor coordination difficulties often feel ashamed of their poor ability to perform many motor tasks, especially those required to participate in sports and to achieve skills in school (eg, cutting with scissors, coloring, drawing, and writing).

The manifestations described above are based on the assumption that children have the opportunity to practice motor activities and are taught them. Children require a minimum of exposure and practice to develop dexterity with scissors and drawing. A child who is notably neglected or not exposed to usual physical tasks may have physical deficits for these reasons.

Crucial aspects of motor development include the following:

- Exposure to tasks
- Caretakers who recognize the child's developmental needs
- Opportunities for the child to be taught skills
- Appropriate stimulation of the child
- Opportunities for the child to develop and practice new movements

These aspects are part of the dynamic theory of motor development, which postulates that children develop new motor skills as they are needed, depending on the interactions with the environment and on the challenges presented. Practice, experience, and environment are important determinants of development, in addition to the child's intrinsic genetic capacities. Development is shaped by a process of selection in which children develop movement repertoires that are optimal for functioning in their specific environmental conditions.

The clinical picture of motor coordination problems is assessed from a developmental point of view—that is, by considering normal physical capacities at different ages. Evaluation of a child's development includes a consideration of individual variation (eg, by factoring in the range of time at which motor skills are normally acquired). Evaluating the overall development of a child is preferable; the characteristic style, strengths, and weaknesses of each child must be taken into account.

Manifestations in infancy

Infants with difficulties in motor functioning may appear either hypertonic or hypotonic. If infants react strongly to any slight auditory or visual stimulation by becoming stiff or by arching the back, this is a sign of hypertonicity and hyperreactivity. Young infants maintain flexor tone in the first few months of life and only gradually develop extension patterns. Newborns that lay in a frog-leg posture suggest hypotonicity.

When parents report that their baby is strong (ie, that the muscles appear hard and tense), this merits careful examination of motor patterns. Clinicians should allow for individual variations; however, if primitive reflexes (eg, Moro, plantar, or rooting reflex) persist after 6 or 7 months, concern regarding motor development is warranted. A single sign may be insignificant, but persistence of several primitive reflexes should elicit full examination of motor functioning and overall development.

Anecdotal data suggest that infants in some racial groups (eg, African Americans) generally achieve gross motor skills more quickly than children of other racial groups. When small infants appear almost ready to walk at a few months of life, this is a

sign for concern. Infants who move as an entire unit without correcting the angle of the head toward the vertical line when held sideways may have a motor developmental problem.

Infants with motor challenges are often delayed in achieving milestones such as the ability to roll over, to sit with help, and to sit without help. Infants with motor problems may not be able to sustain their weight after 6 months when supported under their arms. They have a tendency to slip through the supporter's grasp. This signals muscular hypotonicity.

At about age 4 months, infants can start anticipating the movement of objects, showing early visuomotor development. They should also be able to pull to a sitting position without head-lag and be able to maintain their body in extension when suspended in horizontal posture; persisting head-lag or floppiness during suspension are indicative of hypotonicity.

At about age 6 months, infants can usually oppose the thumb in the grasping motion. Most infants can sit without support also around this age.

By age 9 months, while sitting by themselves, infants should be able to self-correct posture when tilted to one side or the other, rather than just being tipped over. In some infants, these self-correcting (postural) reflexes are absent. Infants also develop a refined pincer grasp around this age. If the infant is not able to sit unassisted by age 9 months, this deficit should concern the clinician and prompt detailed examination.

Infants who stand and who always point down with their toes may also be signaling hypertonicity of the lower limbs (or generalized hypertonicity) and high sensitivity to touch in the plantar surface of the feet. These infants may later walk on their tiptoes.

Scratching the bottom of the foot may elicit an upgoing big toe (positive Babinski sign) in the first year of life, but this should revert to a downgoing toe by age 10-12 months. Persistence of the Babinski reflex is a sign of hypertonicity.

Crossed-adductor reflexes and clonus at the ankles may be seen during the neonatal period, but persistence of these is evidence of hypotonicity.

Manifestations in the second and third years of life

Subtle difficulties in motor functioning may be difficult to identify in the early years of life. For instance, toddlers who have subtle motor skills deficits in chewing may not accept foods that require greater chewing ability. Eating solid food requires the coordinated functioning of approximately 31 pairs of muscles and the coordination of breathing with the swallowing of the bolus. Toddlers who do not eat solids may be displaying a marker of motor challenge that extends beyond chewing. This also applies to toddlers who repeatedly choke on chewed food.

Children may have difficulty in making a pincer grasp (ie, picking up small objects with the index finger and the thumb). A pincer grasp normally appears around month 8 or 9 but may appear later. It can be tested by allowing children to pick up a small object (eg, a piece of breakfast cereal) from a flat surface. Infants may continue trying to pick up these objects with a palmar grasp (ie, with the whole anterior surface of the hand). If so, they should be observed for fine motor delay.

At the end of the first year of life, most infants start making efforts to walk while holding onto furniture and take their first steps shortly afterward. Infants who are unable to walk by age 18 months may have hypotonicity or hypertonicity, poor muscular strength or coordination, or difficulty with managing equilibrium, balance, and posture. In a 1990 study by Bax et al, most children who did not walk at age 18 months turned out to be healthy, but a small percentage had motor difficulties, including cerebral palsy and other developmental delays.[21]

The ability to walk depends largely on the capacity to maintain balance and not fall over. Walking takes more than the sheer muscular strength required to support the weight; the challenge is to displace the weight in a controlled fashion without falling. Both abilities are necessary, however. Other factors involved in walking onset include temperament style, opportunity, and motivational factors.

Manifestations in preschool- and school-aged children

At age 3-5 years, many skills are acquired and refined with exposure to activities and games that require motor practicing. Obviously, children differ from one another in the speed of their development; accordingly, strict dates or milestones of age that are totally accurate cannot be established.

By age 2 years, many children can make a brief 2-foot takeoff jump if someone holds their hands. At age 3-4 years, most children can hop on 1 foot; with the dominant leg, they can hop about 3 times. At age 5-6 years, children can typically perform this hopping about 10 times. By age 5 years, most children can jump about 3 feet in distance and about 1 foot in height.

By age 4-5 years, most children have developed a clear hand preference or dominance. Lack of a hand preference may signal that the normal dominance and specialization of the brain hemispheres is not occurring. Such children do many things with either hand or with 1 hand at some times and the other hand at different times.

In some cases, true ambidexterity is present (the ability to actually perform tasks well with either hand). However, in many cases, the brain is not developing adequate specialization of neuronal pathways to permit control of motor function with one hemisphere. In those cases, the clinician can observe hesitations and the inability to select one side or the other, resulting in relative clumsiness in both limbs.

Alternatively, children may demonstrate early hand preference. This indicates that the nondominant side may be weak or poorly coordinated, and investigations are warranted to determine whether a structural cause is present.

Another sign that is cause for concern is difficulty with maturation of pencil grasp. Concern arises in children who have sufficient practice opportunities but still cannot hold a pencil with a mature pattern. Occupational therapy is essential for these children; poor quality or difficulty with handwriting can lead to later academic difficulties.

Many experts think that difficulties in fine motor skills (eg, managing the fingers and wrist) are a reflection more of malfunctioning in the proximal areas of the upper limbs than of malfunctioning in other areas.

Children may be unable to handle the pen, crayon, or pencil in the dynamic tripod pattern that is considered the mature and efficient way to tackle writing tasks. During that activity, only the wrist joint moves, while the other joints in the upper limb remain fixed. When the shoulder girdle is weak, however, children must compensate when they have to use the distal part of the upper extremity (fingers and hand). Instead of using the wrist to write, children have to move the entire upper limb to write.

Inability to hold and use a pencil in a typical fashion may indicate a problem in differentiating various muscle areas and activating them at will. Thus, tasks such as writing and painting become less efficient, because children must use extra energy to perform them; controlling the whole limb requires more energy than just controlling the wrist. As a result, children who cannot use the proper grasp tire quickly and report that their hand hurts when writing. After a few minutes of drawing or writing, they may give up entirely because it hurts them to continue.

These problems may be additive because teachers who are unaware of these difficulties may believe that the students are lazy or defiant. In objective terms, affected children are incapable of performing these delicate and fine movements until they maturationally achieve good differentiation of motion between the shoulder joint and the rest of the limb. The condition is treated with programmed exercise to strengthen the shoulder belt, causing weight bearing on the area, and with planned work on the hands to strengthen the shoulder, arm, and forearm.

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Physical Examination

Physical examination can be carried out almost in its entirety in the context of everyday activities or play. The examination should include an assessment of dysmorphic features and abnormal neurologic signs. Activities or tests that evaluate children's strength, speed of movement, sequence of movement, coordination, tone, right and left sides, and ability to perform everyday tasks in a smooth and controlled way are all important. Elements of the neurologic examination can be carried out in the context of play include the following:

- Handshaking or squeezing the examiner's fingers to assess strength
- Throwing and kicking a ball
- Cutting something with a pair of scissors

- Drawing or coloring
- Tying shoes
- Reaching for objects with each hand
- Pointing at objects with a finger outstretched
- Taking off or putting on a coat

For the diagnosis of DCD, the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), emphasizes a marked impairment in the development of motor coordination, which must interfere with academic achievement or with activities of daily living (ADLs).[2] A general medical condition that might explain the trouble with movement control (eg, muscular dystrophy or cerebral palsy) must be excluded, as must intellectual disability and visual impairment. Symptom onset must have been in the early developmental period.

The International Classification of Diseases, Tenth Edition (ICD 10), describes motor skills disorder as a “specific developmental disorder of motor functioning.” It emphasizes that even when no formal neurologic condition is present, careful clinical examination shows marked neurodevelopmental immaturities, perhaps choreiform movements of unsupported limbs or overflow movements (ie, mirror movements).

Other extraneous motor actions often occur when children are attempting a specific complex movement, as well as impaired fine and gross motor coordination. In addition, as in the DSM-5 description, the condition must have existed since early in the child’s life (ie, it is developmental rather than acquired). No marked difficulties in perceptual systems, such as vision or hearing, and no specific neurologic disorder should be present.

There is no universally accepted standard for testing children for motor clumsiness. The main role of the pediatrician is to detect difficulties in motor coordination and development, rather than to engage in systematic or standardized testing or therapy. There are, however, a number of tests and examination techniques that may help identify the problem, with generally comparable results.

Tests to observe tasks and abilities

Tests for observing tasks and abilities include the following:

- Test for sustaining a position against gravity
- Test for motor sequencing
- Nose-finger test
- Moving a limb (feet, legs, thighs, arms, forearms, or hands) against resistance
- Test of energy investment in a movement
- Test of the ability to perceive spatial relations
- Test of fine motor tasks
- Test for gross motor difficulties

Observation of muscular tone in sitting and standing positions gives an impression of the child’s ability to sustain a position against gravity.

Touching the thumb against the other fingers of that hand in sequence, one after the other, is a way of assessing whether the child can sequence movements at a certain speed. The clinician observes for errors in the sequence. Observing each hand and noting the effect of muscles getting tired quickly, which leads to additional errors, is important. In this activity, as in others, fine tremors of the fingers can be observed.

Also observed in testing for motor sequencing is an effect of overflow (performing a similar movement with the opposite side of the body, referred to as mirror movements), which should disappear around age 7-8 years. When children who are affected attempt a fine or difficult motion, one can observe adventitious movements, such as grimacing, sticking the tongue out, or tics (stereotypic vocal or motor manifestations related to stress, boredom, or anxiety).

The nose-finger test is performed to measure fine motor coordination, proprioception, and perception of movements in space.

Moving a limb against resistance allows the examiner to assess the child's strength in different areas. Some youngsters have normal strength in the lower limbs but not in the upper body, or vice versa.

Testing of energy investment in a movement is done to determine whether a child can perform a movement or sequence and how difficult performance of the movement is. This issue is not often considered in the assessment of writing ability or other fine movements. A child may be able to carry out this task, but only by applying great focus and concentration, and writing a few words may take practically all of his or her energy.

Obviously, the child is soon fatigued and unable to maintain this energy-wasting activity for a long time. As a consequence, testing for only a brief period may be misleading, because it may not elicit the sustained effort and tiredness that lead to errors in performance and coordination. Sustained testing better simulates real life, where the child often must sustain an activity (eg, doing homework) for more than 2-3 minutes.

The ability to perceive spatial relations is not, strictly speaking, a motor task; it depends on proprioception and the realization of where one's body is in space. Children with difficulties in these functions may bump into things, crash into people, miscalculate the strength of their movements, or knock down a glass that they are attempting to take from a table.

Tests of fine motor tasks can make use of activities such as coloring, drawing, or building with blocks, which directly reflect the child's fine motor coordination. Engaging children in play with miniature toys (eg, small cups, saucers, silverware in a pretend tea party) helps in assessing their coordination of small movements.

Clinicians rarely examine motor abilities in isolation. After motor difficulties are detected, it may be necessary to investigate other areas (eg, visuomotor coordination); to test for other soft neurologic signs; or to assess attention span, writing, and reading. Deficits in these other areas are frequent comorbidities. Observations by school staff may be valuable because these individuals have daily contact with the children at times when the children are attempting to perform these tasks.

With respect to testing for gross motor difficulties, a physical education teacher or a physical therapist may be a better resource for information about physical ability in children than a classroom teacher would be, as shown in a 1997 study by Piek and Edwards.[6]

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Complications

Many children with clumsiness or motor coordination difficulties also have other difficulties. Common problems that aggravate motor coordination difficulties in children include problems in attention and concentration, as well as attention deficit hyperactivity disorder (ADHD). The condition that Gillberg and Kadesjo described as DAMP (d eficits in a ttention, m otor control, and p erception) syndrome indicates the same connection.[22]

Children with autism spectrum disorders, notably those with Asperger syndrome, have long been reported to have motor clumsiness. The type of motor dysfunction observed in autism has not been properly delineated in an empiric study. A study from Sweden reported that 25% of girls with autism and 32% of those with ADHD met criteria for DCD.[23]

Many children with motor difficulties have speech difficulties (eg, stuttering, problems with phonology, receptive language disorders, or mixed language disorders) and may have problems in written expression and other learning disabilities as well.

These perceptual-learning problems (see Mathematics Learning Disorder and Reading Learning Disorder) may be predominant in visuomotor coordination, perceptual skills, and perception of spatial relations. The problem must be addressed from several points of view and take into account all of the child's challenges.

Children with DCD consistently perform below their peers in ADLs. A study by Wang et al reported that in 8-year-old children who had DCD but were not identified by parents or professionals as exhibiting functional limitations, pervasive difficulties with functional performance of ADLs were evident at home and at school.[24]

Impairment of the ability to perform ADLs also highlights the impact on the activity and fitness levels of children affected with DCD. These children are more likely to be obese or to have poor fitness levels, and studies suggest that they are higher risk for cardiovascular disease as adults.[25, 26, 27, 28, 29] One report suggested that increased physical activity reduced body mass index (BMI) in female children with DCD but increased it in their male counterparts.[30]

A report demonstrated that children with probable DCD had an increased prevalence of self-reported depression and parent-reported mental health difficulties, which were, in part, mediated through associated developmental difficulties, low verbal intelligence quotient (IQ), poor self-esteem, and bullying.[31] Children with DCD can also have higher rates of comorbid learning disabilities, attention deficits, and other impairments in learning.[26, 32]

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DDx

Diagnostic Considerations

In addition to the conditions listed in the differential diagnosis, other problems to be considered include the following:

- Muscular dystrophy
- Congenital hypotonia
- Progressive metabolic disorders
- Ataxia
- Visual disorders
- Diffuse central nervous system (CNS) storage disease
- Slow virus infection
- Congenital brain malformations
- Traumatic brain injury
- Malignancy
- Inflammatory brain disorders
- Autism spectrum disorder[33]

Differential Diagnoses

- [Autism Spectrum Disorder](#)
- [Cerebral Palsy](#)
- Learning Disorder: Written Expression
- [Pediatric Attention Deficit Hyperactivity Disorder \(ADHD\)](#)
- [Pervasive Developmental Disorder](#)

Workup

Approach Considerations

No specific laboratory tests for motor skills disorder exist; however, male children should have a creatine kinase (CK) level checked to evaluate for Duchenne muscular dystrophy. Comorbid conditions (eg, high levels of lead, anemia, iron deficiency, and hypothyroidism) should be ruled out.

Because the condition is not a specific neurologic disorder per se, no imaging studies are typically used in children with motor clumsiness difficulties, provided that the neurologic examination findings are otherwise normal and that nothing in the history or the physical examination suggests an underlying structural or medical/metabolic etiology. Studies have found treadmill testing to be able to differentiate developmental coordination disorder from typical children.[34]

If an underlying etiology is suggested, brain imaging (preferably magnetic resonance imaging [MRI]) is warranted).[35] This is an area currently undergoing active research, with new studies finding subtle differences between children with DCD and control subjects.[36] A study using diffusion tensor imaging and functional MRI demonstrated subtle differences between children with developmental coordination disorder (DCD) and control subjects.[37]

Several approaches to the assessment of children with clumsy motor behavior are available (see below). Some of these assessment approaches are directly linked to proposed treatments or interventions (see Treatment).

No specific histologic patterns exist for these conditions.

Normative Assessment of Functional Skills

The normative functional skills approach draws from traditional developmental theory and remains the cornerstone of motor assessment. Assessment is descriptive and is concerned with acquisition of fundamental motor and functional skills, as referenced against age norms. The most commonly used tests of motor impairment are as follows:[38, 39]

- Movement Assessment Battery for Children (MABC or M-ABC)
- Bruininks-Oseretsky Test of Motor Proficiency (BOTMP)
- Test for Gross Motor Development (TGMD-2)

The original MABC was validated as a reliable method in multiple studies and is the tool most commonly used to screen for DCD in research settings. Designed to yield a general index of motor impairment, the MABC has the following 2 parts:

- A performance test that is designed to be administered individually and that requires the child to perform a series of motor tasks in a standard way
- A checklist that is designed to be completed by an adult familiar with the child's day-to-day motor functioning

The performance part of the MABC covers manual dexterity, ball skills, and static and dynamic balance. The checklist addresses progressively complex interactions between the child and the physical environment; it also has good psychometric properties. The revised version of the MABC, the MABC-2, extended the age range from 4-12 years to 3-16 years.

The BOTMP generates a general motor ability factor and is the diagnostic instrument most commonly used by therapists. It is divided into the following 8 subsections:

- Fine motor precision (eg, cutting out a circle or connecting dots)
- Fine motor integration (eg, copying a star or a square)
- Manual dexterity (eg, transferring pennies, sorting cards, or stringing blocks)
- Bilateral coordination (eg, tapping a foot or finger or jumping jacks)
- Balance (eg, walking forward on a line or standing on one leg on a balance beam)
- Running speed and agility (eg, shuttle run or one-legged side hop)
- Upper-limb coordination (eg, throwing a ball at a target or catching a tossed ball)
- Strength (eg, standing long jump or situps)

The BOTMP has good psychometric properties. It provides norms for children and adolescents aged 4.5-14.5 years, though the revised version (BOT-2) can be used for children aged 4-21 years.

The TGMD-2 looks at 12 gross motor skills, divided into locomotor and object control subtests, and can be used for children aged 3-10 years. Compared with the other tests mentioned above, it is more easily and rapidly administered, but fewer data are available on its use in children with DCD.

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Assessment of General Abilities

The general abilities approach is based on the assumption that sensori-integrative and sensorimotor functions provide the platform for later motor and intellectual development. With this approach, the most commonly used test is the Sensory Integration and Praxis Tests (SIPT). However, less than 50% of the SIPT is related to motor function, and this evaluation is much more commonly studied and cited in the sensory integration literature.[39]

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Neurodevelopmental Evaluation

The neurodevelopmental evaluation includes both a general examination and a neurologic examination, as well as an assessment that focuses on subtle deficits in neural functioning. Several batteries have been designed, including the Touwen test for children with minor neurologic dysfunction (MND) and the Physical and Neurological Examination for Soft Signs (PANESS).[38]

At present, normative data for these tests are lacking. Neurologic soft signs are common in children and adults with schizophrenia, attention deficit hyperactivity disorder (ADHD), and other conditions, and they vary in prevalence according to the age, sex, and culture of the population being considered.[11, 40]

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Dynamic Systems Analysis

The dynamic systems approach to evaluation is based on dynamic systems theory, which describes the dynamic relation between perception and movement. It uses biomechanical or kinematic analysis of movement. The importance of assessing contextual factors that contribute to or limit skill acquisition is emphasized.

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Cognitive Neuroscientific Evaluation

The cognitive neuroscientific approach provides a framework that accounts for the development of motor skills in terms of brain-behavior interactions.

Several hypotheses have been generated by using this framework. For example, the focus on deficits in an internal model of an intended but uninitiated movement (in motor control terms, motor imagery) could explain the difficulties that some children with DCD have with performing tasks that require accurate body-scaled (mental) transformations (eg, remembering modeled movements). Neuroanatomic pathways involved in this include those in the parietal lobe and premotor cortex.

Other hypotheses involving the cognitive neuroscientific framework include motor timing, linking deficits of time perception, and sequential tapping to possible deficits in the cerebellum. Advances in neuroimaging and functional imaging may provide insights into hard signs of neural dysfunction.[37]

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Treatment

Approach Considerations

Typical goals of treatment for children with developmental coordination disorder (DCD) are as follows:

- To ascertain problem areas for a given child in a comprehensive fashion
- To design an intervention that will promote optimal adaptive functioning, the acquisition of skills that are underdeveloped or affected, or the amelioration of coordination difficulties

Several studies focused on the efficacy of therapeutic interventions and even involved comparisons of different methods. In general, these studies showed that the interventions described are helpful and that parents were satisfied with the results. However, no single type of treatment is applicable to all children with motor coordination disorder, nor is any individual treatment successful with all. Existing evidence does not permit the conclusion that any of the methods described below is generally or uniformly better than the others.

This research field is complex because of the different problems in each child and because of the issues of comorbidity, motivation, associated emotional difficulties, and adherence to treatment (particularly with practice sessions at home). Thus, comparisons between patients and treatments are weaker than they would be if all children had the same problem and received the same intervention. Even the issue of intervention is unclear; therapists may think they are using only one method but may unwittingly introduce elements of others.

Two general approaches are used to treat motor coordination problems in children. One approach is a modular (top-down) approach, and the other is a more global or generalized (bottom-up) approach.

Despite a lack of best practice guidelines, there is overwhelming and consistent evidence to show that children who receive interventions such as physical therapy and occupation therapy have better outcomes than children who do not receive interventions.[41, 37]

No specific pharmacologic treatments improve motor performance. In children who have essential tremor severe enough to interfere with motor abilities, propranolol and other beta-blocker agents can be used. No surgical procedures exist to be used in these conditions.

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Pharmacologic Therapy

No medications are specifically designed to improve motor functioning, coordination, or related conditions. Propranolol, like

other beta blockers, has been used to treat intense essential tremor, which sometimes is an associated condition in children with coordination problems, but it should be only prescribed in severe cases and on the advice of a child neurologist. Medications are reserved for the treatment of associated conditions (eg, attention deficit hyperactivity disorder [ADHD]).



Nonpharmacologic Therapy

The first of the 2 general approaches to treatment, the modular or top-down (task-oriented) approach, attempts to remedy or improve specific difficulties by employing specific techniques aimed at the observed motor challenge (eg, difficulty with handwriting, catching a ball, or performing fine motor tasks with the fingers). It usually involves gradually targeting certain problem behaviors and implementing step-by-step interventions that focus on teaching and practicing the skill. This method tends to prevent failure and rewards the child, at least at first.

Because of its circumscribed nature, the modular approach lends itself to implementation by professionals such as schoolteachers. One of its core elements is practice (eg, prescribed practice of new skills and small steps toward mastery of the skill, with success achievable at every small step). Examples of this general approach are therapies such as the cognitive motor approach with task orientation or the task-oriented approaches with motor learning.

The second of the 2 approaches, the more global or generalized one (also described as a bottom-up, process-oriented, or deficit-oriented approach), is based on the theoretical assumption that the motor skills problem is just a manifestation of some underlying mechanism, such as impaired sensory integration or insufficient or inaccurate kinesthetic perceptions.

In the bottom-up approach, the therapist does not initially address the observable motor challenge. Rather, the expert focuses on how children manage their bodies, process stimulation (sensory information), and deal with problems. The expectation is that the improved sensory-motor functioning becomes generalized and eventually improves the motor skills. As children become comfortable with their bodies, they gain control of their motor (and other) functions.

Examples of this school of thought are the kinesthetic training approach, sensorimotor integration therapy, and sensory integration therapy. As with many other forms of intervention and therapy, there is only limited evidence for the efficacy of these methods, particularly over the long term or regarding the end result.

Although the top-down approach is grounded in more current models regarding motor control and learning, and the data suggest that it is more effective than the bottom-up approach, no single approach has yet been substantiated as effective through research studies.[37]

Cognitive motor intervention

Cognitive motor intervention consists of delineating a plan to teach movement patterns or skills to children who have a challenge in that particular task or set of tasks. Therapists design a set of exercises that children practice with the assistance of the parents until the task is learned gradually or mastered.

The emphasis is on motor performance, as well as on emotional, motivational, and cognitive aspects. The trend is toward solving motor deficits. Children are taught how to plan a motor act, how to execute it, and how to evaluate the quality of the result. Motivation of the patient is essential because building self-confidence and positive reinforcement are important goals.

Motor problems are selected, and new skills are taught one at a time to build ability gradually. The ability acquired in one context is expected to be generalizable to others. For example, this could be used for teaching handwriting, catching balls, or increasing speed of movement. Other objectives could be teaching the child to throw a ball overhand and to kick, bounce, and catch a ball. Following the piagetian theory of learning, the therapist hopes to create a schema that children can use later in different situations of successful therapy.

Feedback is important at each step. Concrete positive reinforcers are gradually deemphasized and replaced with emotional reinforcers (eg, the satisfaction of learning new things). One of the advantages of this method is that it offers a measurable goal; therefore, obtaining objective feedback about the development of new concrete skills is possible.

Task-oriented interventions may or may not be helpful in the treatment of children with developmental coordination delay.[42]

Sensory integration therapy

Occupational therapists and physical therapists widely use sensory integration therapy in the treatment of children with certain difficulties that interfere with consistent, coordinated, and effective motor function.

Sensory integration therapy addresses the underlying difficulties many clumsy children have with regulating, processing, and/or integrating sensory input. Accurate, coordinated, and functional motor responses are based on well-modulated, selective, and consistent information from both internal and external sources, which the brain then adequately integrates.

Treatment involves specific input for the particular child and the facilitation of desired adaptive responses. Examples of internal senses are those of posture, proprioception, and awareness of position of the body in general and of limbs and body parts in particular (ie, vestibular input).

External stimuli that may facilitate or hinder performance include auditory stimuli, lighting and visual stimulation, tactile sensations, and others. Children who are excessively affected by such stimulation (and who are, therefore, hypersensitive) are helped to cope with increasing amounts of stimulation, and the environment is modified to provide an acceptable level of sensory input. By way of contrast, in children who are hyposensitive, the amount of stimulation is gradually increased.

In all cases, signs of excessive or inappropriate stimulation are monitored. Techniques for helping the children self-modulate and self-regulate are also useful. Examples are time without stimulation with relaxation and brief periods of isolation to recuperate a state of calmness.

Sensory integration therapy is effective but not necessarily better than other methods. This approach also allows the incorporation of a variety of techniques into the home and classroom to promote improved adaptive function. Examples are methods to provide the extra proprioceptive input that a particular child may seek and need, such as carrying book crates during transitions, holding heavy doors, and chair pushups.

The general idea is that improved sensory integration will lead to more modulated motor responses, better perception of the movements, and improved coordination of fine and gross motor patterns.

A consensus statement from the American Academy of Pediatrics advised that sensory integration disorder should not be diagnosed and that sensory integration therapies have no proven value.[43] The statement advised that sensory integration therapy may be of benefit when combined with occupational therapy but stated that it should be prescribed only after a thorough discussion with the parents regarding the lack of data.

Kinesthetic training

Kinesthetic training relies on the studies carried out by Laszlo and Bairstow on kinesthetic development in children.[44] This approach involves enhance kinesthetic sensitivity in children so as to improve motor control, with the intent of reducing perceptual-motor dysfunction.

Although this approach is popular, it has generated controversies regarding the successes the authors have claimed. Its aim is to generate improvement in children's overall functioning in terms of perception of motion, but unlike other methods, it does not focus on teaching them specific skills. The theoretical rationale for kinesthetic training is that when general awareness of motion in space is improved, motor skills presumable will also improve as a secondary effect.

Neurodevelopmental treatment

The basic principles of the neurodevelopmental treatment approach, first described by Karl and Bertha Bobath in the 1940s, involve inhibiting primitive (persisting) reflexes and abnormal motor coordination patterns while promoting higher-level reactions and normal muscular tone and movement patterns. Accordingly, emphasis is placed on the following:

- Detailed evaluation of the patterns of development observed in the small child
- Diagnosing the child's developmental level
- Designing a strategy to restore development to as normal a level as possible and to improve skills as much as possible

Craniosacral therapy

Craniosacral therapy was devised by the osteopathic physician John E Upledger. Trained therapists from a variety of professional backgrounds use highly sensitive palpation skills to address imbalances in the craniosacral system. This treatment is reported to be successful mostly in children who have the most compromised motor skills, who have some spasticity or hypertonia, and who have an abundance of health problems, including motor coordination difficulties.

Osteopathic and chiropractic therapy

Segmental dysfunctions such as those commonly treated with manual therapy techniques are unlikely to be the cause of DCD; rather, they may be a consequence. A study indicated that in children with other comorbid processes, some improvements in motor skills may be enhanced with manual treatments.[45]

Visual training

Visual training is an approach that some optometrists or trained occupational therapists use to address specific difficulties with oculomotor function. Some visually related difficulties or difficulties with visual-motor integration interfere with coordinated motor skill performance and equilibrium. The American Academy of Pediatrics has officially deemed this visual training of eye movements to be ineffective and unacceptable.[46]

Assistive technology

In addition to various therapies, assistive technology is used to develop adaptive methods of enhancing function in children with motor difficulties. These modifications range from the simple (eg, attaching special pencil grips that make the pencil easier for the child to grasp) to the complex (eg, making voice-responsive computers available for children with writing difficulties).

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Diet and Activity

No special diet is recommended for children with motor skills disorders, nor has any diet been demonstrated to improve the motor functioning of children.

By definition, activities and motor functioning are essential for the treatment of children with DCD. In addition to the treatment offered by occupational therapists or motor rehabilitation specialists, parents and other caregivers can provide considerable assistance for children at home in the form of specifically designed games and activities that could help improve the children's motor functioning and self-esteem.

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Consultations

Evaluation by an occupational therapist with experience in assessing all aspects of motor functioning and sensory integration abilities is useful in characterizing the problem. An occupational therapist can also assist in developing an intervention strategy. A physical therapist with experience in evaluating children can help design beneficial programs for children with coordination problems.

In cases where concomitant learning disabilities are present, consultation with a specialist in psychoeducational testing (eg, a psychologist or a teacher with this training) can assist in designing a treatment strategy.

Problems with attention span and hyperactivity are often associated with motor skills problems, as well as with difficulties in behavior and self-esteem. If these interfere with the child's academic performance, motivation, or attitude toward learning, consultation with a medical professional (eg, a child psychiatrist, pediatric neuropsychologist or pediatric developmental specialist) is indicated.

If a more global neurologic concern is present (eg, global developmental delay, developmental regression, abnormal head size, worrisome neurologic examination findings, or other concerns), referral to a child neurologist is warranted.



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