Why Bother About Clumsiness? The Implications of Having Developmental Coordination Disorder (DCD)

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ABSTRACT

Developmental coordination disorder (DCD) is a common motor problem affecting—even in rather severe form—several percent of school age children. In the past, DCD has usually been called 'clumsy child syndrome' or 'non-cerebral-palsy motor-perception dysfunction'. This disorder is more common in boys than in girls and is very often associated with psychopathology, particularly with attention-deficit/hyperactivity disorder (ADHD) and autism spectrum disorders/ autistic-type problems. Conversely, children with ADHD and autism spectrum problems, particularly those given a diagnosis of Asperger syndrome, have a very high rate of comorbid DCD. Psychiatrists appear to be unaware of this type of comorbidity in their young patients. Neurologists, on the other hand, usually pay little attention to the striking behavioral and emotional problems shown by so many of their 'clumsy' patients. A need exists for a much clearer focus on DCD—in child psychiatry and in child neurology—both in research and in clinical practice.

KEYWORDS

DCD, ADHD, autism, psychiatric disorders, clumsy child syndrome

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INTRODUCTION

Most clinicians and researchers are, by now, well aware that childhood onset neuropsychiatric disorders, including attention-deficit/hyperactivity disorder (ADHD) and autistic disorder/Asperger syndrome, are often comorbid with other psychiatric disorders, including affective and anxiety disorders (Biederman, 1997), illicit drug use (Hechtman, 1996), antisocial behavior, oppositional defiant disorders and conduct disorder (Taylor, 1986), tics, and learning disorders (Barkley, 1990). Much less well known is that such conditions are also associated with motor control dysfunction, 'clumsiness', and the so-called developmental coordination disorder (DCD) (APA, 1994). Motor clumsiness and DCD (Table 1) have been seen as the territory of child neurologists and developmental pediatricians, whereas attention deficit disorders/ ADHD, autism spectrum disorders, and other psychiatric disorders are conceptualized as falling within the domain of child psychiatry. Possibly this 'split' accounts for few psychiatrists being aware of the motor and perceptual problems that are so often comorbid with childhood neuro-psychiatric disorders. Conversely, child neurologists, often fail to appreciate the impact of neuro-psychiatric symptoms in clumsy children referred to them for diagnosis and work-up.

In this brief review, we aim to demonstrate that the links between DCD and behavior problems, notably ADHD and autism spectrum disorders, are quite strong and must be taken into account, both in clinical practice and research.

TABLE 1

Diagnostic criteria for Developmental Coordination Disorder (DCD)

A.	Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This may be manifested by marked delay in achieving motor milestones (e.g. walking, crawling, sitting), dropping things, "clumsiness", poor performance in sports or poor handwriting.
B.	The disturbance in Criterion A significantly interferes with academic achievement or activities of daily living.
C.	If Mental Retardation is present, the motor difficulties are in excess of those usually associated with it.

American Psychiatric Association (1994)

To do so, I must acquaint the reader with the basic concepts in the field of DCD and briefly review the literature on mild-moderate motor impairment as a kind of neurodevelopmental dysfunction.

MOTOR IMPAIRMENT AS REFLECTING NEURODEVELOPMENTAL DYSFUNCTION

The interest in mild and moderate motor control problems in children grew out of a study of the so-called minimal brain dysfunction (MBD) syndromes. Minimal brain dysfunction was a diagnostic term for children having normal (or near-normal) intelligence but who nevertheless had varying degrees of learning and behavior problems associated with brain dysfunction (Clements, 1966). These 'MBD-problems' were thought of as manifesting themselves in various combinations of deficits in attention, motor control, perception, impulse control, language, and memory (to mention the most important). The diagnosis of MBD relied on the documentation of these deficits and particularly motor control and perception problems or on the demonstration of 'soft neurological signs' or motor deficits that were believed to reflect brain dysfunction but for which structural neurological correlates had not been identified (Tupper, 1987). Deficits in motor control or the occurrence of soft neurological signs were regarded as a more reliable reflection of the 'integrity of the central nervous system' than more 'purely' behavior variables (such as impulsivity, oppositional behaviors, compulsions). Clumsiness and poor motor coordination were seen as clear markers of neurological dysfunction (Denckla & Rudel, 1978).

Various 'neurodevelopmental tests' (as complements to classic neurological examination) were developed to study these neurological dyfunctions more reliably (Henderson, 1987). Most tests consist of a battery of items intended to measure a child's neuromotor maturity. Many tests that are in use are fairly comprehensive and include items that are not pure 'motor' but involve perceptual, intellectual, and language functions as well (Michelson et al., 1981, Bax & Whitmore, 1987, Rasmussen et al., 1983). Some tests, however, are more specifically focused on the child's neuromotor performance (Hadders-Algra et al., 1988).

Several motor dysfunction screening tests have been developed (Gillberg et al., 1983, Glascoe et al., 1990, Kadesjö & Gillberg, 1998). Each test is fairly condensed and easy to apply in clinical practice. The screening device for motor disco-ordination, developed in the longitudinal 1978 Swedish (Göteborg) study of perceptual, motor and attention deficits (Gillberg et al., 1983), is shown in Table 1. A very similar, slightly more elaborate test was used by Kadesjö and Gillberg (1998) in a total population study of neuropsychiatric and neurodevelopmental

TABLE 2

Brief neurodevelopmental screening (BNS) for motor dyscoordination/DCD developed by Gillberg et al (1983)

A.	Age-inappropriate performance on items included under B. Child only allowed one attempt per item. Test developed for 6- to 7-year-olds. In this age-group abnormality on 2 or more of the 6 items suggests presence of DCD. Other cut-offs apply in younger (higher cut-off)) and older (lower cut-off) children.
B.	The six BNS items: 1) Jumping up and down 20 times on one foot, left and right scored separately. Abnormality: (a) >12 secs, or (b) 2 or more interruptions on any one foot. 2) Standing on one foot, left and right scored separately. Abnormality: <10 secs on any one foot. 3) Walking on lateral aspects of feet for 10 secs (also referred to as the Fog test) with hands hanging down (swing allowed). Abnormality: (a) elbow flexed 60 degrees or more, (b) abduction of shoulder, (c) significant associated movements of lips or tongue, or (d) significant asymmetry. 4) Diadochokinesis 10 secs, each hand separately. Abnormality: (a) 10 or fewer pro-supinations on either side, (b) significant "dysfluency", or (c) lateral elbow movements of 15 cms or more. 5) Cutting out a paper circle (10 cms diameter) from a rectangular sheet. Abnormality: (a) 20% or more of paper circle cut "away", (b) 20% or more of extra material remaining outside paper circle, or (c) 2 minutes or more used for task. 6) Tracing task using pencil and paper. Abnormality: according to specific test used.

disorders performed in another part of Sweden (Karlstad) in 1990. For final diagnosis other, more elaborate tests have been developed (Touwen, 1979; Drillien & Drummond, 1983; Rasmussen et al., 1983).

The association between motor control problems and behavior disturbance/learning disorder was acknowledged early on (Kephart, 1971; Ayres, 1972). From the results of association studies, conclusions about causal relations were drawn. A 'movement' grew out of this, focusing on motor training programs aimed at alleviating learning and behavior problems. Unfortunately, a meta-analysis of 180 studies of perceptual-motor training (Kavale & Mattson, 1983) revealed that such training will not affect "academic, cognitive or perceptual-motor variables" other than those being trained.

Studies differ in respect of delineation and terminology in the field of 'minor neurodevelopmental deviations (MND)'. Some terms that have been used include 'soft neurological signs' (Tupper, 1987), and 'minor neurological dysfunction (also abbreviated MND) (Hadders-Algra & Touwen, 1992). Prevalence figures vary (Duel & Robinson, 1987) but have often been estimated at about 5%. Some studies have reported much higher rates. In a Dutch study (Hadders-Algra & Touwen, 1992), 15% of the school-age population was judged to have mild MND and another 6% had severe MND (boys twice as often as girls). The term MND in that study referred to neurological deviance that does not result in obvious disability (for example minor dyscoordination, fine motor deviance, choreiform movements, and abnormalities of muscular tone). The 'MND-tradition' regards motor dysfunction (at least the severe variant) as a sign of a neurological disorder, which may also cause or be associated with other problems like language and perception dysfunction.

DEVELOPMENTAL COORDINATION DISORDER

A slightly different tradition antedates the emergence of the clumsy child (Gordon & McKinlay, 1980) and DCD concepts. Certain children lack the motor skills required for such everyday activities as play, sports, and school work. Such children are not generally delayed and they usually do not have an easily identifiable neurological disorder. The motor difficulties as such are regarded as important, regardless of whether they should be interpreted as a sign of neurological disorder. The DSM-system acknowledges this group of children in the DSM-III-R (APA, 1987), in which DCD is defined as motor coordination performance markedly below the expected level (namely, inappropriate for age and IQ), causing significant interference with academic achievement or activities of daily living. The DSM-IV-definition (Table 1) is very similar. Before the DSM-era, children with DCD were described as 'motor impaired', 'motor delayed', 'physically awkward', 'perceptuomotor dysfunction'/ 'motor-perceptual dysfunction (MPD)', 'developmentally agnostic/apractic', or as 'clumsy child syndrome' (Gubbay, 1975, Gordon, 1980, Gillberg & Rasmussen, 1982).

The DSM-definitions do not provide clear cut-offs vis-a-vis normality. Children's environments are variable with regard to the demands and expectations of motor performance. Tradition and culture determine the child's experience of motor activities. DCD is often stated to occur at a rate of about 5% of the general child population, but Henderson (Henderson & Sugden, 1992) is of the opinion that another 10% have similar but milder problems. 'Poor coordination' was found in 8.1% of about 30,000 7-year-olds followed in the Perinatal Collaborative Project (Nichols, 1987). In another study of 1443 children 6 to 12 years of age, the rate of such problems varied from 5.4% at age 6 years to 1.3% at age 10 years (van Dellen et al., 1990).

Children with DCD differ with regard to

a. the severity and type of motor difficulties (Hoare, 1994),
b. the pattern of performance in other domains (intellectual, educational and behavioral) (Henderson & Hall, 1982), and
c. background factors such as genetic and perinatal problems (Gillberg & Rasmussen, 1982; Hadders-Algra & Touwen, 1992).

Henderson (1987) developed a descriptive and functional assessment method for the evaluation of DCD. The focus of this examination is *how* the child performs a task that is meaningful to the child—regardless of underlying cause—and that can be carried out by non-medical staff. Possibly the best known of these are the TOMI (Test of Motor Impairment, Stott et al., 1984) and its successor, the Movement ABC (Movement Assessment Battery for Children) (Henderson & Sugden, 1992). Results on the TOMI correspond to teacher ratings of clumsiness, estimated to occur in about 5% of children in a normal class-room (Henderson & Hall, 1982).

Attempts to find the cause of DCD have resulted in theories of 'processing deficits' being at the root of poor motor performance (Schoemaker & Kalverboer, 1990, Schellekens, 1990). Such processing deficits could be either generally reduced rates of information processing or more specific deficits in handling spatial information that is relevant to the control of movement (Henderson et al., 1994). This view would be partly and indirectly supported by recent findings that at school age, very low birth weight children (< 1800g) have a very high rate of difficulty in arithmetic, as well as an extremely high rate (around 40% to 50%) of DCD (Holsti et al., 2002).

A series of studies performed by Hulme and coworkers (Lord & Hulme, 1987) revealed an

increased rate of visuospatial discrimination impairment in children with clumsiness. Henderson et al. (1994) could not find a straight-forward relation between perceptual and motor impairment. Henderson concludes, contrary to Hulme, "...that the defective processes are not essentially visual but involve strategic processes which may not be modality specific."

Other authors reported an increased rate of kinesthetic perceptual difficulties in clumsy children (Sugden & Wann, 1987; Piek & Coleman-Carmen, 1995), and dysfunction of kinesthetic perception has been forwarded as an underlying primary deficit that can account for secondary motor control problems (Piek & Coleman-Carmen, 1995). Sims (Sims et al., 1996a; 1996b) showed, however, that improved motor performance resulted after 'kinesthetic training', as well as after motor training that did not include kinesthetic elements, suggesting that in designing remediation programs for clumsy children, the way that training is presented may be as important as its actual content.

ADHD AND AUTISM SPECTRUM DISORDERS PERTAINING TO THE STUDY OF CLUMSINESS: BRIEF LITERATURE REVIEW

Several studies by DeMyer (1972), Denckla (1978; 1985), Wolff et al. (1990), and Gillberg et al. (1982; 1993; Landgren et al., 1996; Kadesjö & Gillberg, 1999) showed a strong relation between ADHD and autism spectrum disorders on the one hand and DCD/dyscoordination/MPD on the other. Other authors (Szatmari, 1989; Witmont, 1996) reported similar findings.

Several Swedish studies have shown a rate of about one in two children with ADHD also having DCD. In a study of a total population of 7-year olds in the city of Karlstad in middle Sweden in the mid-1990s, 47% of children meeting full DSM-III-R criteria for ADHD also met operationally defined criteria for DCD (Kadesjö & Gillberg, 1999). Of all children having 5 or more ADHD symptoms, almost half had DCD, compared with less than 1 in 10 of those with 4 or fewer ADHD symptoms. Very similar rates of comorbidity were obtained in a population study of 3448 6- to 7-year olds performed in the city of Göteborg in western Sweden 20 years earlier (Gillberg et al., 1982). An extrapolation of the findings from that study indicates that 50% of the children meeting operationalized criteria for ADD also met strict criteria for MPD (motor-perception dysfunction). The rate of comorbidity of ADHD and MPD was very similar in another population-based study from Sweden, performed in the early 1990s, with roughly half of all 6-year-olds with ADHD meeting the criteria for MPD (which, in turn, was almost identical to DCD) (Landgren et al., 1996).

In a study designed to determine whether hyperactive children, who had neither learning disability nor subtle *traditional* neurological soft signs, might have measurable anomalies for their age on a brief examination of *motor coordination*, Denckla (1978) found that this was indeed the case. She used some measures similar to those employed in the Swedish studies, but included more tests of rapid alternating coordination (toe-taps, heel-toe, finger repetition, diadochokinesis, hand pats, and finger to thumb). Associated movements and 'motor overflow' were also evaluated and found to be the strongest discriminators between boys with hyperactivity and those without. In other words, the ability to carry out discrete isolated movements was seriously impaired (for example, activating a flexor muscle in one finger while simultaneously inhibiting the flexor muscles of the other fingers). Denckla interpreted these overflow movements as a sign of deficient motor inhibition or motor control, and she considers this a crucial deficit in the syndrome of hyperactivity.

Interestingly, Barkley (1990)—who estimated that more than 50% of children with ADHD have

poor motor coordination—proposed that the decreased ability to delay responding might be a core feature of ADHD (Barkley, 1997). This symptom seems to be very similar to that described by Denckla (1978), who also examined groups of children with dyslexia with or without comorbid ADD, and found that those with comorbidity had deficient precision and rhythm, overflow movements, and slowness, despite having a slightly higher IQ than did those with 'simply dyslexia' (Denckla, 1985). Denckla concluded that motor speed and inhibition appear to be useful as objectively observable and less environmentally influenced, examinable 'neighborhood signs' of behavioral control. She further states,

> *History and questionnaire data constitute primary criteria for a diagnosis of ADD, but motor developmental status may provide a valuable link to understanding underlying mechanisms or physiological components of the elusive mental state.*

Similar views seem to be held by van der Meere and co-workers (1991), who conclude that input processing is not disturbed in ADHD, but that motor output is dysfunctional. Timing, pacing (like the ability to slow down to become more thorough when solving a task after having performed an error) and preparation to act are all deficient. In fact, a remarkable association has been found between ADHD and motor control/motor output problems, such that it seems reasonable to postulate that ADHD might primarily be a failure in the areas of intention, inhibition, and capacity to delay responding, or a 'motor state regulation problem' (Denckla, 1996).

Children with autism spectrum disorders, notably those with Asperger syndrome, have long been reported to suffer from the kind of motor clumsiness currently subsumed under the DCD-label (Asperger, 1944; Wing, 1981; Gillberg, 1991). Denckla (1978) noted visuo-motor deficits in autism already in the 1970s. Only recently has it become generally accepted that motor control problems may be part and parcel of the autism spectrum syndromes (Teitelbaum et al., 1998; Ghaziuddin & Butler, 1998). Nevertheless, the type of motor dysfunction seen in autism has not yet been properly delineated in empirical study.

DCD AND ATTENTION DEFICITS, AUTISM SPECTRUM PROBLEMS, AND OTHER PSYCHIATRIC DISORDERS/PROBLEMS: BRIEF LITERATURE REVIEW

Few studies have looked at in detail the comorbidity of attention, behavioral, or emotional problems in DCD. In fact, apart from the Swedish studies reviewed above, ADHD as such has not been examined in direct relation to DCD. In the study by Kadesjö and Gillberg (1998), "subclinical or clinical ADHD" was obtained in 55% of individuals with "clinical DCD". The term subclinical in that study referred to cases meeting all but one or two of the symptom criteria for ADHD. About one in five with clinical DCD showed the full syndrome of clinical ADHD.

Whitmore and Bax studied 5-year-old children and followed them up 2 and 5 years later. The authors found that of children with deviant neurodevelopmental scores at age 5 years, 25% to 46% had learning disorder or behavior problems at follow-up (compared with 4% to 8% of children without abnormal neurodevelopmental scores).

Gillberg found that 65% of children with MPD have ADD (Gillberg et al., 1989). Taken with the figure of 50% of ADD children having MPD—and the general population figures for ADD and MPD—it seems blatantly clear that attention deficit and clumsiness are associated in a fashion very much stronger than chance would predict.

In the study of DCD in Karlstad, Sweden (Kadesjö & Gillberg, 1998), a strong link between

the presence of motor control problems and Asperger syndrome symptoms was found. Thus, for instance, children with DCD had on average 3 of 19 possible Asperger syndrome symptoms, compared with 0.1 in the group without DCD ($p < 0.001$).

Increased rates of behavior problems, affective disorders, school adjustment difficulties, and other social problems have been reported in children with motor control problems (Gillberg & Gillberg, 1989; Losse et al., 1991; Gueze & Börger, 1993; Michelsson & Lindahl, 1993; Cantell et al., 1994). Compared with other children, clumsy children are reportedly more introverted and have less self-confidence with respect to physical and social skills (Schoemaker & Kalverboer, 1990). They often have a feeling of inferiority (Gordon & McKinlay, 1980), low self-esteem (Skinner & Piek, 2001), and are less well liked in their peer group (Gubbay, 1975).

THE NORDIC CONCEPT OF DEFICITS IN ATTENTION, MOTOR CONTROL, AND PERCEPTION (DAMP)

Because of the documented strong association between attention and motor control problems in research and clinical practice, and because of the difficulty of separating out which domain (attention or motor-perceptual) should be regarded as primary, the concept of *deficits in attention, motor control, and perception* (DAMP) was launched in the Nordic countries in the early 1980s (Gillberg et al., 1982). DAMP was conceptualized as the interface between ADD and MPD (or, in more modern terminology ADHD and DCD). Population studies of prevalence, descriptive, and etiological studies were performed in many centers in the Nordic countries. Follow-up and follow-back studies (for example, Gillberg, 1985; Hellgren et al., 1993; Hellgren et al., 1994; Kadesjö & Gillberg, 1998; Kadesjö, 2000) revealed that DAMP had stronger validity in terms of common background factors and poorer psychosocial/academic outcome than did either ADHD or DCD. The DAMP-construct has now been in wide-spread use in the Nordic countries for about 15 years and is the preferred terminology according to a consensus (Airaksinen et al., 1991). This approach has replaced the old MBD-concept and is also receiving increasing research attention in other countries, including the United States (Tervo et al., 2002). Although an on-going discussion is in progress on whether ADHD or DCD might be the preferred diagnostic terms for reasons of 'purity', there is a widespread realization that ADHD is so often associated with motor control problems that a term acknowledging both types of deficit is needed in clinical practice. On the basis of the literature review presented in this chapter, we feel that DAMP has a lot to be said for it and that, in the wake of follow-up studies demonstrating better validity for ADHD, should be seriously considered in other parts of the world as well. The term in itself suggests to the clinician that areas other than attention-related problems would have to be explored for a fuller understanding of the problems faced by each individual child.

CLINICAL IMPLICATIONS

Developmental Coordination Disorder is strongly associated with attention deficits/ADHD, Asperger syndrome, and other autism spectrum disorder symptoms. Conversely, in about half of all cases, ADHD is associated with DCD. If less stringent criteria for diagnosing ADHD are applied, then the rate of associated clumsiness goes up. This observation means that any clinician dealing with DCD must be aware of its strong link with ADHD and autism spectrum disorder, and ADHD/autism specialists have to know about the very strong association with motor impairment and be able to diagnose motor control problems in their patients.

Several well-researched screening instruments (in particular the TOMI, the Movement ABC, and the screening devices designed by the Swedish group) are suitable for clinical purposes. Some children with ADHD have such severe problems with motor functions that individually designed training programs are required. Others can be helped by recognizing the problems and providing educational and psychological support along with a change of attitude among teachers and peers. To what extent—if any—the treatment of ADHD (such as with stimulants) might affect the course of the associated DCD is unknown. Motor training programs do not appear to affect the outcome of ADHD or other behavior problems. In the light of current knowledge, it would seem prudent to conclude that attention problems, autism spectrum disorders, and motor control deficits have to be investigated separately. Some studies do suggest that they may be intrinsically entwined, and one might therefore reasonably argue that treatment of an underlying deficit might help alleviate several different types of problems. Yet, we still have but rudimentary evidence in this field, and a need exists for intensified research efforts. What is beyond any reasonable doubt is that ADHD and autism spectrum disorders are strongly associated with DCD. This aspect has to be appreciated by child psychiatrists, by child neurologists, and by developmental pediatricians alike so that children affected can benefit from state-of-the-art evaluation and intervention.

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