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Are children with childhood apraxia of speech a subgroup of children with developmental coordination disorders?

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ABSTRACT

Motor development is related to various aspects of human development, from speaking to taking care of oneself and participating in sports. Developmental disorder affecting the motor domain is known as Developmental Coordination Disorder (DCD), which results in a marked impairment in motor skills, which in turn can have a significant impact on activities of everyday living (American Psychiatric Association, 2013). Several studies have shown that the motor deficit in DCD is not restricted to limb control and may be a more general phenomenon that could affect the speech motor system (Ho and Wilmut, 2010). According to Maassen (2002), there is strong evidence that delayed or deviant motor development and perceptual motor learning play a role in many children with childhood apraxia of speech (CAS). Knowing that articulation is a mechanical act executed by the complex speech apparatus, could this potentially mean that children with CAS are a subgroup of children with DCD? Different studies demonstrated that children with CAS had problems with various aspects of nonspeech oral motor function (Tükel, Björeljus, Henningsson, McAllister and Eliasson, 2015), as well as balance, aiming and catching (Iuzzini-Siegel, 2019). Further evidences of impaired motor skills could help us understand the underpinnings of CAS.

Keywords:

Developmental Coordination Disorder ▪ motor development ▪ Childhood Apraxia of Speech

INTRODUCTION

There are numerous actions or movements we do daily, from walking and driving to speaking. Some of them we do automatically, without thinking about them, while others may seem more complex like a ballet pirouette. Praxis (from Greek) refers to the doing of an action; hence dys- or apraxia would refer to a disorder in the performance of an action.

Motor development is related to various aspects of child's development, from speaking to taking care of themselves at home or participating in sports. If your child displays some kind of motor impairment, which cannot be attributed to a general medical condition or intellectual disability, but it is interfering with its daily activities and/or academic achievement, he or she might have a motor disorder. A developmental disorder affecting the motor domain is known as Developmental Coordination Disorder (DCD), which results in a marked impairment in motor skills, which in turn can have a significant impact on activities of everyday living, such as dressing, playing sports, holding a knife and fork or handwriting (American Psychiatric Association, 2013). On the other hand, if speech is the only affected domain of motor development, then one could think of Childhood apraxia of speech (CAS), childhood motor speech disorder with core deficit in child's ability to convert abstract phonological codes to motor speech commands (ASHA, 2007). It is known that motor skills play a critical role in early development and shape child's learning environment (Libertus and Violi, 2016). That is why it is important to look at a bigger picture, because these impairments have a lot of similarities which will be discussed further in the paper.

What is Developmental Coordination Disorder (DCD)?

For a long time, DCD has been under recognized and rarely diagnosed by general practitioners and pediatricians (Harris, Mickelson and Zwicker, 2015). Since its discovery, DCD has been known under a variety of labels such as developmental dyspraxia, minimal brain dysfunction, perceptuo-motor dysfunction, physical awkwardness and, most commonly, the "clumsy child syndrome" (Missiuna, Gaines and Pollock, 2002). Magalhaes, Missiuna and Wong (2006) reported that more than nine terms were used to define DCD in several countries and across several disciplines such as medicine, education and psychology. In order to improve communication and knowledge among clinicians and researchers working with this disorder, an international consensus meeting was held in London, Ontario in 1994, where the term DCD was accepted (Zwicker, Missiuna, Harris and Boyd, 2012).

Developmental Coordination Disorder (DCD) is defined as a neuro-developmental disorder characterized by diminished fine and/or gross motor coordination that affects approximately 5–6 % of children (American Psychiatric Association, 2013). According to Harris et al. (2015) DCD could be recognized in a child whose parents, caregivers or teachers expresses concerns that he or she is unusually clumsy and is showing persistent delays in gross or fine motor milestones.

As described in the latest edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), in order to be diagnosed with DCD, a child has to display motor coordination below expectations for his or her chronologic age, may have been previously described as clumsy and may have had delays in early motor milestones, such as walking and crawling (American Psychiatric Association, 2013). Difficulties with coordination of either gross or fine motor movements, or both, interfere with academic achievement or activities of daily living. As mentioned before, coordination difficulties do not relate to a medical condition, disease (e.g., cerebral palsy, muscular dystrophy, visual impairment or intellectual disability) or intellectual disability. In the previous DSM edition, DCD was included under the broad category of "learning disorders" while in DSM-5, it is subcategorized under motor disorders within the broader category of "neurodevelopmental disorders" (F82).

Table 1. DSM-5. Diagnostic criteria for DCD, (American Psychiatric Association, 2013, p. 74)

A.	The acquisition and execution of coordinated motor skills is substantially below expected, given the individual's chronological age and opportunity for skill learning and use. Difficulties are manifested as "clumsiness" (e.g., dropping or bumping into objects) as well as slowness and inaccuracy of performance of motor skills (e.g., catching an object, using scissors or cutlery, handwriting, riding a bike, or participating in sports).
B.	The motor skills deficit in Criterion A significantly and persistently interferes with activities of daily living appropriate for chronological age (e.g., self-care and self-maintenance) and impacts academic/school productivity, prevocational and vocational activities, leisure and play.
C.	Onset of symptoms is in the early developmental period.
D.	The motor skills deficits are not better explained by intellectual disability (intellectual developmental disorder) or visual impairment and are not attributable to a neurological condition affecting movement (e.g., cerebral palsy, muscular dystrophy, degenerative disorder).

Just like children with other types of developmental disabilities, children with DCD do not "outgrow" their disorder and become more coordinated, but there is less research considering DCD in adulthood. According to research, there is a frequent comorbidity of DCD with other childhood disorders such as attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder or specific learning disabilities (Harris et al., 2015).

Why should speech and language pathologists be able to recognize characteristics and behaviors of children with DCD?

As mentioned before, research has demonstrated the high co-occurrence of DCD with other childhood disorders

(Visser, 2003). Hill's (2001) review of literature concerning motor skill in specific language impairment (SLI) has highlighted that many studies have found significant movement difficulties. That substantial comorbidity between SLI and poor motor skills could suggest that SLI, in fact may not be a specific disorder of language.

If we know that approximately 70 % of the children who present "specific" speech/language impairments may also show features of DCD (Blank, Smits-Engelsman, Polatajko and Wilson, 2011), and movement difficulties seen in children with SLI are very similar to those seen in children with DCD (Hill, 2001), then there are strong theoretical reasons to believe that the underlying mechanism of both disorders may be shared.

Visscher, Houwen, Scherder, Moolenaar and Hartman (2007) investigated the motor profiles of 125 children with developmental speech and language disorders and tested the differences in motor profile among subgroups of children with developmental speech and language disorders. When compared to the norms of the Movement Assessment Battery for Children, children with developmental speech and language disorders performed significantly worse. 51 % of the children with developmental speech and language disorders had borderline or definite motor problems. According to Visscher et al. (2007), speech and language disorders seem to have more impact on motor performance than language disorders, and it seemed that when speech production was affected, motor problems were more pronounced. If we take into consideration the fact that the development of speech articulation throughout adolescence underlines the complexity of this skill, then the underlying deficits in motor control mechanisms in disordered speech could suggest that the development of speech articulation may be an area particularly susceptible to a general deficit in motor function (Ho and Wilmut, 2010). Empirical evidence supports this hypothesis with findings suggesting that fine motor skills between 12 to 18 months and at 24 months predict expressive language skills at 36 months of age in infants (LeBarton and Iverson, 2013). All these findings demonstrate that mastering certain motor milestones could be related to subsequent language development (Libertus and Violi, 2016).

Small-scale pilot study conducted by Ho and Wilmut (2010) suggested that children with DCD who did not display apparent speech and language problems tended towards an atypical pattern of lip movement during more complex speech tasks. These early results showed that the motor deficit in DCD is not restricted to limb control and may be a more general phenomenon that could affect the speech motor system.

Considering the fact that that pediatricians make more referrals to speech and language pathologists compared to other allied health professions (Michaud and Committee on Children with Disabilities, 2004), being the first professional in contact with children, gives them an important role in assessing children who may be in need of speech and language support, physical and occupational therapy. Early recognition of these symptoms can improve outcomes of children with DCD because they are highly susceptible to secondary consequences of poor motor skills such as physical and mental health (Caçola and Killian, 2018) and school failure if combined with speech and language difficulties.

Childhood apraxia of speech – features and prevalence

Hodge (1998) hypothesized that children with suspected childhood apraxia of speech are a subgroup of a larger population of children who exhibit developmental coordination disorders affecting the speech sensorimotor system. We know that articulation of speech is a mechanical act executed by a complex speech apparatus including infralaryngeal (lungs), laryngeal, and supralaryngeal (tongue, lips), and the underlying deficits in motor control mechanisms in disordered speech suggest that the development of speech articulation may be particularly susceptible to a general deficit in motor function involvement, as well as neural control mechanisms (Ho and Wilmut, 2010). Could this mean that children with DCD might be at risk of having CAS or vice versa?

Childhood apraxia of speech (CAS) is a neurological childhood speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (abnormal reflexes, abnormal tone). The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody (ASHA, 2007). Similarly to DCD, CAS is a complex and controversial diagnostic label, despite being recognized over a century ago (Ozanne, 2005). According to ASHA's 2007 consensus, there are three segmental and suprasegmental features consistent with the deficit in planning and programming of movements for speech (a) inconsistent errors on consonants and vowels in repeated productions of syllables or words, (b) lengthened and disrupted coarticulatory transitions between sounds and syllables, and (c) inappropriate prosody, especially in the realization of lexical or phrasal stress. In addition to these core features of CAS, children may also have co-occurring impairments affecting non-speech oral motor function, language, phonemic awareness/meta-linguistics and literacy (ASHA, 2007). Even though there are a number of speech, language, oro-motor and other characteristics of children with CAS listed in literature, a single diagnostic characteristic identifying all children with CAS marker is missing (Ozzane, 2010). The appropriate minimum age for the diagnosis of CAS appear to range from under 2 years of age to under 4 years of age, including both children with idiopathic CAS and with CAS as a secondary symptom in neurological and complex neurobehavioral disorders (ASHA, 2007). Strand (2003) suggests giving the diagnosis after the child has the ability to imitate utterances that vary in length and phonetic complexity. If children display potential signs such as presence of vowel distortions and small phonetic and phonemic inventories, they should be monitored rather than given the diagnosis (Strand, 2003).

There are no epidemiological data on the prevalence of CAS, but the prevalence has reportedly increased substantially during the past decade (ASHA, 2007). According to Shriberg, Aram and Kwiatkowski (1997a) and their preliminary population estimate, based only on clinical referral data, CAS may occur in one to two children in a thousand.

Stackhouse (1992a) listed 47 symptoms of CAS under the headings of Phonetics, Clinical, Cognitive and Language. Not all the features associated with CAS are speech behaviors; some of them are gross/fine-motor incoordination-

on, body dyspraxia/body awareness in space, dyspraxia for isolated and/or sequences oro-motor movements. According to Maassen (2002), there is a strong evidence that delayed or deviant motor development and perceptual motor learning play a role in many children with childhood apraxia of speech (CAS). Difficulties with oral motor coordination, such as closing lips to blow bubbles or blowing out birthday candles, was also reported in children with DCD (Harris et al., 2015). Does this mean that these two clinical populations overlap? Is this one larger population as Hodge has hypothesized? Unfortunately, the current situation is far from resolved. Research on generalized motor function in children with symptoms and/or diagnosis of CAS is limited and results are ambiguous (Iuzzini-Siegel, 2019).

These ambiguous findings may be due to methodological shortcomings, instrument sensitivity or differences in CAS diagnostic criteria. Several clinical studies have investigated key characteristics for CAS reported by speech and language pathologists based on English speaking (Forrest, 2003; Joffe and Pring, 2008) and Swedish speaking children (Malmenholt et al., 2017). In fact, Forrest (2003) reported high degrees of clinical disagreement among practicing SLPs in their criteria for diagnosing CAS, which can consequently lead to misdiagnosing false positives or false negatives.

Clumsiness is frequently reported in children (McCabe, Rosenthal and McLeod, 1998) and according to Bradford and Dodd (1996), children with CAS may evidence a generalized deficit in motor planning while in children with inconsistent speech disorder, fine motor deficits could relate to a difficulty of incorporating timing into complex motor plans.

Iuzzini-Siegel (2019) investigated fine and gross motor ability in children with idiopathic CAS and control groups of children with typical development (TD) and non-CAS speech sound disorders (SSD) with Movement Assessment Battery for Children (Movement ABC), which has good sensitivity and validity. Results showed that CAS group did not perform significantly worse than control groups on *Manual Dexterity tasks*, but they did present significantly poorer performance than other groups on the *Balance* and *Aiming and Catching* components. Furthermore, CAS group scored more than one standard deviation below the mean on all components of the Movement ABC-2 whereas the SSD and TD groups scored within the normal range on these motor assessments. After reclassifying groups according to language impairment (LI), and only small samples were included, it is important to recognize that 7/7 children in the CAS+LI group evidenced motor impairments compared with only 2/6 in the SSD+LI group. This could suggest that language impairment alone did not likely account for the substantially higher percentage of children with motor impairments observed in the CAS+LI group. These findings represent preliminary evidence that there may be a clinically meaningful difference in the motor abilities of subgroups of children with CAS (Iuzzini-Siegel, 2019). Tükel et al. (2015) study demonstrated that children with CAS had problems with various aspects of speech/nonspeech oral motor function. Manual and overall motor functions and adaptive behavior were also affected, but to a lesser degree. These overlapping problems between

DCD and CAS should be taken into consideration when discussing core global motor deficit in CAS.

CONCLUSION

Developmental disorder affecting motor domain is known as Developmental Coordination Disorder (DCD). Depending on the severity of a child's motor impairment, fine and gross motor deficits may continue into adolescence and adulthood and impact mobility, self-feeding, self-care, writing, participation in physical and athletic activities and academic success (Miller, Missiuna, Macnab, Malloy-Miller and Polatajko, 2001).

Why should this matter to a speech and language pathologist? If we are aware that there is a high prevalence and co-occurrence of speech and language disabilities and motor skill deficits, and that speech and language pathologists are among first professionals in contact with children (Michaud and Committee on Children with Disabilities, 2004), this means that they have an important role in assessing children who may be in need of speech and language support, physical and occupational therapy.

To date there is no validated list of diagnostic features that differentiates CAS from other speech sound disorders. Since there is no unique behavioral or neurological marker of CAS, the disorder is usually recognized by general characteristics of CAS proposed by ASHA (2007). Considering the fact that there are reported motor planning and coordination problems in children with CAS (such as difficulties with handwriting or learning to tie shoelaces), which are similar to those also found in children with DCD (Visser, 2003), it is important to take them into consideration when doing the assessment.

At this moment there is a gap in our knowledge as to what extent children with CAS evidence impairment in motor skills distinctive for DCD, but the evidence of impaired motor skills could help us understand the underpinnings of CAS. That is why future studies are needed; to characterize the fine/gross motor skills of children with CAS and to understand the functional limitations of motor impairments among children with CAS (Iuzzini-Siegel, 2019). Collaboration between speech and language pathologists, special educators, physical and occupational therapists is needed to thoroughly investigate and understand motor profiles associated with this population and provide them with optimal assessment and intervention.

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