The Co-Occurrence of Possible Developmental Coordination Disorder and Suspected Childhood Apraxia of Speech

La cooccurrence d'un potentiel trouble développemental de la coordination chez les enfants soupçonnés d'avoir une dyspraxie verbale

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Abstract

Childhood Apraxia of Speech is a communication disorder characterized by deficits in planning and programming speech motor movements. Developmental Coordination Disorder is a neurodevelopmental disorder affecting the ability to plan and execute motor movements. The co-occurrence of Developmental Coordination Disorder and Childhood Apraxia of Speech is unknown. This study explored whether the prevalence of possible Developmental Coordination Disorder in a population of children with suspected Childhood Apraxia of Speech would be greater than the occurrence of Developmental Coordination Disorder in the general population. A sample of 35 children with suspected Childhood Apraxia of Speech was recruited and parents completed a Developmental Coordination Disorder screening questionnaire. Results indicated that children with suspected Childhood Apraxia of Speech were identified as being at greater risk for also having possible Developmental Coordination Disorder than are children in the general population for Developmental Coordination Disorder. The percentage of children (49%) with co-occurring suspected Childhood Apraxia of Speech and possible Developmental Coordination Disorder in the sample was significantly greater than the percentage of children (9%) with Developmental Coordination Disorder in the general population. Results support the need for a population-based prevalence study. Outcomes support the need for speech-language pathologists to implement multidisciplinary practice, early identification, and early intervention for this population.

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La dyspraxie verbale est un trouble de la communication caractérisé par des déficits dans la planification et la programmation motrice des mouvements de la parole. Le trouble développemental de la coordination est, quant à lui, un trouble neurodéveloppemental qui affecte la planification et l'exécution motrice des mouvements. Or, la présence (ou absence) d'une cooccurrence de ces troubles chez un même individu n'est pas connue. La présente étude a exploré si la prévalence d'un potentiel trouble développemental de la coordination était plus élevée chez une population d'enfants soupçonnés d'avoir une dyspraxie verbale que chez des enfants provenant de la population générale. Trente-cinq enfants soupçonnés d'avoir une dyspraxie verbale ont été recrutés et il a été demandé à leurs parents de remplir un questionnaire de dépistage du trouble développemental de la coordination. Les résultats ont montré que les enfants soupçonnés d'avoir une dyspraxie verbale étaient plus à risque que les enfants provenant de la population générale de se faire également identifier un possible trouble développemental de la coordination. Le pourcentage d'enfants de l'échantillon chez qui était noté un possible trouble développemental de la coordination (49%) était significativement plus élevé que celui des enfants provenant de la population générale (9%). Ces résultats supportent la nécessité d'effectuer une étude de prévalence portant sur l'ensemble de la population. Ces résultats supportent également le rôle des orthophonistes dans la mise en œuvre d'une pratique multidisciplinaire, ainsi que dans le dépistage et l'intervention précoce du trouble développemental de la coordination chez les enfants soupçonnés d'avoir une dyspraxie verbale.

Childhood Apraxia of Speech

Childhood Apraxia of Speech (CAS) is a communication disorder characterized by deficits in planning and programming speech motor movements. CAS has been defined as

> A neurological childhood speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits.... The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody (American Speech-Language-Hearing Association [ASHA], 2007, para. 3).

The prevalence of CAS is currently unknown (ASHA, 2007). Clinical referral data suggests that CAS occurs in approximately 1–2 children per 1,000 (Shriberg, Aram, & Kwiatkowski, 1997) and in about 3%–4% of children with speech sound disorders (Delaney & Kent, 2004). Children with CAS can present at many different ages and in many different ways but are inclusively thought to have difficulty with planning and programming movements for speech (Ozanne, 2005). CAS appears to be the result of a neurological deficit, either idiopathic or as a result of impairment (ASHA, 2007).

The ability to describe CAS has improved, which has led to earlier identification. In practice, speech-language pathologists (S-LPs) often use clinical judgment and a combination of formal and informal measures to identify suspected Childhood Apraxia of Speech (sCAS; Strand, 2017). According to ASHA (2007), "at present, there is no validated list of diagnostic features of CAS that differentiates this symptom complex from other types of childhood speech sound disorders" (para. 3), but therapists often consider three consensus-based features: (a) inconsistent vowel and consonant errors, (b) lengthened and disrupted transitions between sounds and syllables, and (c) inappropriate prosody (intonation/stress).

In our clinical experience, S-LPs might not formally diagnose CAS, particularly in very young children, due to a lack of established diagnostic features. However, they may refer to a child as having sCAS when assessing speech and language skills, setting goals with families, and delivering treatment. Based on the literature, clinical judgments about sCAS are often made with the understanding that (a) there is a continuum of severity, (b) a child does not need to display every characteristic associated with CAS, and (c) characteristics of the disorder may change over time (Davis & Velleman, 2000). As part of diagnostic best practice, it is recommended that a period of treatment (i.e., 6 to 12 months) be delivered. If, after this period, speech intelligibility remains low and the motor control features of CAS remain, a firm diagnosis can be made (Davis & Velleman, 2000).

Developmental Coordination Disorder

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder in which "the acquisition and execution of coordinated motor skills is substantially below that expected given the individual's chronological age and opportunity for skill learning and use" (American Psychiatric Association, 2013, p. 76). When motor impairments significantly impact a child's ability to perform activities of daily living (i.e., self-care, academic productivity, and leisure activities at home, at school, and in the community) and cognitive disability, visual impairment, and other neurological conditions affecting movement are ruled out, a diagnosis of DCD can be considered. DCD occurs in 5%–6% of the population (American Psychiatric Association, 2013) with prevalence estimates varying by location from 5%–19% (Barnhart, Davenport, Epps, & Nordquist, 2003; Lingam, Hunt, Golding, Jongmans, & Emond, 2009; Slater, Hillier, & Civetta, 2010; Tsiotra et al., 2006; Zoia, Barnett, Wilson, & Hill, 2006) and 8% in Canada (Tsiotra et al., 2006). The cause of DCD is unknown, although neuroimaging studies have shown distinct brain differences in children with DCD compared to typically developing children (Zwicker, Missiuna, Harris, & Boyd, 2010, 2011, 2012).

In order to identify possible Developmental Coordination Disorder (pDCD), a screening tool may be used. Parent report has been established as a reliable source for helping to screen children not only for speech and language difficulties but also for motor difficulties—Webster, Majnemer, Platt, and Shevell (2005) used the Battelle Developmental Inventory and Gaines and Missiuna (2007) used the Child Development Inventory. The Developmental Coordination Disorder Questionnaire (DCDQ; Wilson et al., 2009) and the Little Developmental Coordination Disorder Questionnaire-Canadian Edition (Little DCDQ-CA; Rihtman, Wilson, & Parush, 2011; Wilson et al., 2015) are valid and reliable parent report tools for identification of pDCD in children 3 to 15 years of age.

The Relationship Between Childhood Apraxia of Speech and Developmental Coordination Disorder

Language disorders involve difficulty using and/or understanding words and sentences, while speech disorders involve difficulty articulating specific speech sounds. Studies show that children with developmental speech and language disorders often have motor skills

that lag behind those of typically developing peers (see Rechetnikov & Maitra, 2009, for a review of speech-language disorders and motor skills) and that speech disorders—as compared to language disorders—may be more strongly correlated with poor gross motor skills (Visscher et al., 2010). More specifically, research has shown that both fine and gross motor impairments increase when speech or speech and language difficulties, as opposed to language only, are evident (Bishop, 2002; DiDonato-Brumbach & Goffman, 2014; Visscher et al., 2010; Visscher, Houwen, Scherder, Moolenaar, & Hartman, 2007). Visscher et al. (2010) concluded that a strong relationship exists between motor performance and speech as both require complex motor planning, programming, and execution.

The co-occurrence of motor difficulties and CAS has been explored further. In a longitudinal study of children at risk for familial CAS, Highman, Hennessey, Leitão, and Piek (2013) found that children at risk for CAS scored lower on measures of fine motor skills compared to children with no such family history. Hall (2000b) described possible associated factors with CAS reported in the literature, including gross-motor and fine-motor difficulties. Similarly, Davis and Velleman (2000) have described motor characteristics that may co-occur with CAS, including use of gestures to communicate, fine and gross motor delays, and motor clumsiness. Hodge (1998) described the parallels between DCD and CAS and questioned whether or not DCD could be initially detected in the speech motor system. In her theoretical model, Hodge (1998) discussed the possibility that DCD is the overarching sensorimotor disorder and is inclusive of a developmental speech coordination component. There has since been some evidence to suggest that the characteristics of DCD may also affect the speech motor system. For example, Ho and Wilmut (2010) found that children with DCD showed significantly different patterns of motor control, compared to typically developing children, during a complex sentence production task requiring a fast rate of speech.

A number of neuroimaging studies have indicated neurological differences between typically developing children and children diagnosed with DCD that could be contributing to motor planning and execution deficits. Biotteau et al. (2016) summarized these neuroimaging findings to conclude that the cerebellum, basal ganglia, parietal lobe, and limbic system could be involved. Brown-Lum and Zwicker (2017) summarized current functional magnetic resonance imaging studies that report (a) differences in brain activation, (b) differences in the corticospinal tract (motor) and the posterior thalamic radiations (sensory), (c) under-activation of the cerebellum, (d) deficits in the cerebellar network (i.e., connections to the frontal and parietal areas), and (e) differences in the cortical regions associated with working memory and executive function. Despite these neuroimaging studies, findings remain inconclusive in describing a unique structural or functional neural network signature for DCD. Regarding the neural correlates of speech production, Price (2012) reviewed research that highlighted the brain areas associated with heard speech, speech production, and reading, including the cerebellum's role in word generation. Broca's area and the supplementary motor area also have also been associated with speech movements, including planning and initiating sequential complex movements of speech articulators. Additionally, using functional magnetic resonance imaging, Redle et al. (2015) found that clients with persistent speech sound disorders demonstrated different patterns of brain activation than controls during a finger tapping task. Overall, the literature appears to suggest that both DCD and CAS may have similar underlying neural correlates, most notably the function of the cerebellum (Brown-Lum & Zwicker, 2017).

The treatment of both CAS and DCD may be more efficient and effective if conducted early and in a collaborative manner. In general, difficulties with communication and motor skills can significantly impact academic achievement and social participation; early assessment, diagnosis, and management by a multidisciplinary team is recommended in order to implement holistic, timely interventions and supports in an effort to minimize short- and long-term impacts (Hall 2000b, 2000c; Iverson & Braddock, 2011; Rechetnikov & Maitra, 2009; Visscher et al., 2010; Webster et al., 2005). More specifically, the research on CAS suggests that it is a complex motor speech disorder that may be best supported by a multidisciplinary team approach to treatment (Teverovsky, Bickel, & Feldman, 2009). As well, early identification and treatment of DCD is essential to the enhancement of participation in typical activities of childhood across all environments and the reduction of often devastating secondary consequences (i.e., anxiety, low self-esteem, poor self-efficacy, and limited participation; Engel-Yeger, 2015). Therefore, if a significant co-occurrence between these two disorders is found, then early identification and multidisciplinary treatment approaches targeting both disorders may prove to be both efficient and effective.

Present Study

To date, we are unaware of any study that specifically examines the co-occurrence of DCD and CAS. Because CAS is an impairment in planning and programming motor

movements for speech, it follows that children identified as having sCAS may have broader underlying motor impairments and might therefore meet the criteria for DCD. It is possible that the prevalence of DCD in this population may be higher than in the typically developing population.

To address this gap in the literature, the purpose of this pilot study was to describe the co-occurrence of pDCD and sCAS in Alberta Health Services, Central Zone East, Children's Rehabilitation Services. We aimed to determine how many children between the ages of 3 and 15 years currently receiving services from community rehabilitation S-LPs in Alberta Health Services, Central Zone East, for sCAS would obtain scores on DCD parent questionnaires identifying them with pDCD. Central Zone East is a rural service area in Central Alberta where the general population is 122,057. Approximately 31,203 people in Central Zone East fell between the ages of 0–18 at the time of this study. The number of children aged 0–18 referred to Children's Rehabilitation Services for developmental concerns in 2016 was 1,423.

We hypothesized that the prevalence of pDCD in a population of children with sCAS would be greater than the occurrence of DCD in the general population. We also hypothesized that the proportion of children having both sCAS and pDCD in our present sample would be significantly greater than the proportion of children having the single diagnosis of DCD in the general population, implying that the sample population is unique.

The possible benefits from the outcomes of this project include (a) the advancement of our understanding about the possible co-occurrence of DCD and CAS, (b) the ability to characterize the potential involvement of a multidisciplinary team of clinicians in the early identification and treatment of sCAS and pDCD, and (c) to translate findings to daily practice locally, provincially, and nationally in a relatively short period of time.

Method

Participants

Ethics approval was received for this study from the Health-Research Ethics Board-Health Panel at the University of Alberta (Pro00067090). Potential participants were excluded from this study if they had been diagnosed with any known genetic, neurological, sensory, intellectual, or emotional disorder or deficit, cerebral palsy, a degenerative idiopathic motor disorder, or a traumatic brain injury, as per DCD differential diagnosis lists by Kirby, Sugden, and Purcell (2014) and Missiuna, Gaines, and Soucie (2006).

A convenience sample of children between the ages of 3 and 15 years receiving treatment for sCAS was recruited from Central Zone East. S-LPs working with these children identified them[1], asked their families if they would be interested in learning more about the study, and, if so, obtained informed consent to pass their name, contact information, and an sCAS checklist (developed for the purpose of this study and completed by the child's S-LP; see Appendix) to the research team.

Measures

The demographic form was created by the research team and included information about the targeted child and family related to age, sex, number of siblings, comorbidities (i.e., Attention Deficit Hyperactivity Disorder, autism, learning disability, language disability, dysarthria, executive function, joint hypermobility syndrome, anxiety, depression, overweight/obese, other), perceived physical activity level, household income, and level of parent education. Items on the demographic form were later used to describe the study population.

Physical activity level that appears in the demographics (see **Table 1** and **Table 2**) was parent-rated using the Canadian Physical Activity Guidelines (Canadian Society for Exercise Physiology, n.d.), which states that a child between the ages of 4 and 17 should participate in at least one hour of moderate to high intensity physical activity every day. Parents were asked to rate their perceptions of the targeted child's level of physical activity (not including gym class if school age). These perceptual categories included (a) very active (more than one hour of physical activity per day including extracurricular activities), (b) active (about an hour of vigorous physical activity per day), (c) somewhat active (2–4 hours of vigorous physical activity per week), and (d) prefers quiet activity (Canadian Society for Exercise Physiology, n.d.). Physical activity level was coded from the demographic form as 4 = *very active* (i.e., more than one hour of vigorous physical activity per day with involvement in extracurricular physical activities), 3 = *active* (i.e., about an hour of vigorous physical activity per day), 2 = *somewhat active* (i.e., 2–4 hours of vigorous physical activity per week), and 1 = *prefers quiet time* (e.g., reading, board games).

[1] Alberta Health Services Central Zone East speech-language pathologists (S-LPs) received six one-hour motor speech education sessions via Adobe Connect once a month from January to June 2016. Pre- and post-test results were compared and showed that S-LPs made significant gains in knowledge and confidence in providing all aspects (i.e., identification and intervention) of motor speech services. The results of this Motor Speech Education Project will be considered in establishing a motor speech education program for S-LPs in the province of Alberta (Forst, Meintzer, Klassen, & McAllister, n.d.).

Developmental Coordination Disorder questionnaires. Parents of 3–4 year-old children completed the Little Developmental Coordination Disorder Questionnaire-Canadian Edition (Little DCDQ-CA; Wilson et al., 2009), and parents of 5–15 year-old children completed the Developmental Coordination Disorder Questionnaire (DCDQ; Rihtman et al., 2011; Wilson et al., 2015). These questionnaires ask parents to use a 5-point Likert scale to compare their child's motor skills and coordination in everyday functional activities to those of their peers. Each questionnaire consists of 15 items that can be categorized into 3 factors (control during movement, fine motor, and general motor) for the DCDQ and 2 factors (fine motor and gross motor) for the Little DCDQ-CA (Wilson et al., 2009; Wilson et al., 2015). The Little DCDQ-CA and the DCDQ each yield a total score out of 75 and cutoff scores based on gender (Little DCDQ-CA) or age (DCDQ) indicate whether or not a child is suspect for DCD (Wilson et al., 2009; Wilson et al., 2015). The overall sensitivity for the DCDQ is 84.6% and specificity is 70.8% (Wilson et al., 2009). The Little DCDQ-CA reports sensitivity between 80% and 86% with specificity ranging from 49% to 63% (Wilson et al., 2015). The Little DCDQ-CA and the DCDQ were scored according to respective test protocols.

Suspected Childhood Apraxia of Speech checklist. The sCAS checklist was completed and submitted to the study team by the treating S-LP. Presently, there is no validated list of diagnostic features for CAS (ASHA, 2007). Therefore, the sCAS checklist developed and used in the present study included key characteristics based on the literature (see Appendix). This checklist was not developed as a tool to identify sCAS; rather, its purpose was to describe the speech characteristics of children already on caseload for sCAS.

A four-cluster arrangement of CAS descriptors was compiled based on Ozanne (2005) and guided by others (i.e., Apraxia Kids, n.d.; ASHA, 2007; Davis & Velleman, 2000; Fish, 2015; Hall, 2000a; Strand, 2017). *Cluster 1* characteristics describe phonological planning, *Cluster 2* characteristics describe motor programming, *Cluster 3* characteristics describe motor planning, and *Cluster 4* characteristics describe prosodic errors and negative history for babbling. Strand (2017) discussed several key characteristics of CAS (those "often present" and those "more discriminative") that help distinguish CAS from a more typical phonological impairment. Examples of these characteristics include a range of items from all four of the clusters in the compiled sCAS checklist, providing justification for their inclusion and the subsequent equal weighting given to each cluster in our analysis. An sCAS severity score was calculated by weighting equally all four clusters of the sCAS checklist to account for different numbers of items within each cluster. For each cluster, participants were assigned a percentage score based on the number of characteristics checked out of a given number of items in that cluster. Total scores from all four clusters were added and averaged for a total severity score percentage.

Procedure

Families who expressed interest in participating were contacted by a research team member who discussed the study, gained consent for participation, and sent a demographic form and age-relevant DCD questionnaire by mail or email. If the study team was unable to contact families on the first attempt or if families began but did not complete the study measures online, follow-up phone calls were made.

Data were collected from February to May of 2017. Following data collection, de-identified questionnaires were scored by the study team[2]. After surveys, demographic forms, and sCAS checklists were completed, the data were de-identified and assigned a participant number.

Data Analysis

Our main research question was to find out if children with sCAS would have a greater likelihood of being identified as also having pDCD compared to children being identified as having a single diagnosis of DCD in the general population. Our hypothesis was that the occurrence of pDCD in a population of children with sCAS would be significantly greater than the occurrence of DCD in the general population. To address this question, a binomial test was used to test the probability of pDCD in our present sample against DCD in the general population. In our study, two possible outcomes existed: having pDCD or not. We wanted to determine whether the likelihood of having pDCD was greater than chance alone. Based

[2] Families who participated were mailed a letter informing them whether their child's score fell in the probable Developmental Coordination Disorder range. If children scored in the probable Developmental Coordination Disorder range, parents were given the option to discuss further occupational therapy and physical therapy follow-up and assessment if interested.

on the literature, the prevalence of DCD in the general population is 5%–6% (American Psychiatric Association, 2013); we used the more conservative population 9% prevalence value for this test (Slater et al., 2010), as choosing this higher estimate allows for a more cautious comparison of our current study sample to the population sample.

Our second hypothesis was that our sample of children with sCAS and pDCD would reflect a different population group than individuals having only DCD identified in the general population. We employed a two-sample *z* test to compare the sample proportion of children with pDCD to the proportion of DCD in the general population.

Results

Participants

Parents of 35 out of 63 identified children participated, resulting in a response rate of 61.4%. Of the participating children, 31 were boys and 4 were girls. Demographic data relevant to these participants are detailed in **Table 1** and **Table 2**. The pDCD scores (representing total score on the Little DCDQ-CA or DCDQ) and the sCAS scores (including total sCAS score from the entire checklist and respective cluster scores, both as a percentage) are also listed.

Probability Statistics

In the present study, 17 of 35 participants scored below the cutoff for pDCD. We found that the probability of having exactly or more than 17 cases of pDCD in a sample of 35 is significantly greater than the probability of having a single diagnosis of DCD in the general population ($p < .0001$, 1-tailed). Thus, we can accept our hypothesis stating that the occurrence of pDCD in a population of children with sCAS is greater than the occurrence of a single diagnosis of DCD found in the general population.

Next, we wanted to determine whether or not 17 of 35 cases were significantly different from 10,985 of 122,057 (9% of the Central Zone East population). A *z* score of 8.3, $p < .0001$, indicated that the percentage of children (49%) that have co-occurring sCAS and pDCD in the present sample is significantly different than the percentage of children (9%) in the general population (see **Figure 1**). The 95% confidence intervals depicted in **Figure 1** suggest that the sample of children with sCAS and pDCD does not overlap with the general population of DCD and, therefore, likely describes a distinct group. Thus, we can accept our hypothesis that the two populations (i.e., the study population and general population) are distinctly different.

Table 1

Demographic Information for the Younger Group (3–4 Year Olds; *n* = 18): Little DCDQ-CA

	Age (months)	DCD Score	sCAS Total Score (%)	Cluster 1 Score (%)	Cluster 2 Score (%)	Cluster 3 Score (%)	Cluster 4 Score (%)	Physical Activity (Range = 1 to 4)	Number of Comorbidities
M	47.44	64/75	40.47	69.75	31.11	54.70	6.35	3.39	0.72
SD	7.22	10.98	17.11	25.79	27.63	24.02	13.17	0.78	0.57
Range	36–59	37–75	14.32– 77.14	11.11–100	0–80	30.77–100	0–28.57	2–4	0–2

Note. Cutoff score for "Suspect DCD" is 68 or below. A total of 56% of younger children fell below the cutoff score. DCD = Developmental Coordination Disorder; Little DCDQ-CA = Little Developmental Coordination Disorder Questionnaire-Canadian Edition; sCAS = suspected Childhood Apraxia of Speech.

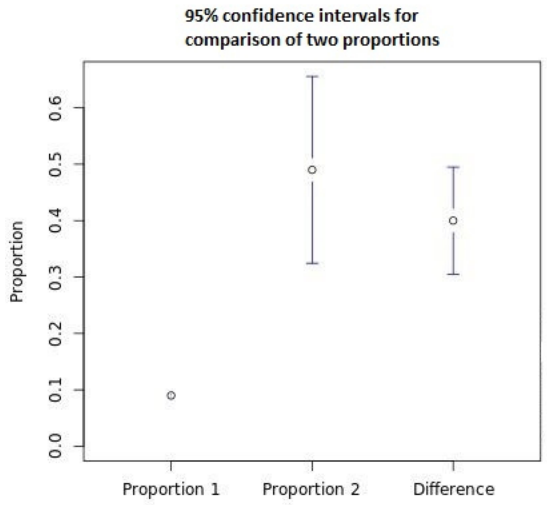
Table 2

Demographic Information for the Older Group (5–15 Year Olds; *n* =17): DCDQ

	Age (months)	DCD Score	sCAS Total Score (%)	Cluster 1 Score (%)	Cluster 2 Score (%)	Cluster 3 Score (%)	Cluster 4 Score (%)	Physical Activity (Range = 1 to 4)	Comorbidities
M	89.17	54.2/75	42.80	58.17	40	52.03	21.01	3.24	0.59
SD	25.79	12.33	19.18	29.80	27.39	28.85	24.28	0.83	0.62
Range	61–159	32–73	7.48–85.93	0–100	0–80	7.69–100	0–71.43	1–4	0–2

Note. Cutoff score for "Suspect DCD" is 46 or below for 5–7.11 years, 55 or below 8–9.11 years, 57 or below for 10–15 years. A total of 41% of older children fell below the cutoff score. DCD = Developmental Coordination Disorder; DCDQ = Developmental Coordination Disorder Questionnaire; sCAS = suspected Childhood Apraxia of Speech.

Figure 1



Two sample *z* test for the comparison of two proportions. Proportion 1 represents the likely proportion of Developmental Coordination Disorder cases in Central Zone East based on general population using a conservative estimate of 9% (range 5%–9%; Slater et al., 2010). Proportion 2 represents the proportion of possible Developmental Coordination Disorder cases in the study sample of children with suspected Childhood Apraxia of Speech. The "Difference" represents the difference between the two proportions. The 95% confidence intervals are represented by the blue error bars.

Discussion

Identification of Possible Developmental Coordination Disorder in Suspected Childhood Apraxia of Speech

This pilot study provided an initial evaluation of the co-occurrence of sCAS and pDCD in children ranging from 3–15 years of age. Data from the present study sample of children with sCAS showed a significantly higher proportion of pDCD (49%) than the 5%–9% (Slater et al., 2010) of individuals with DCD in the general population. Given the proportion confidence intervals for our sample and for the general population, it is unlikely that we are simply identifying individuals with DCD but rather a distinct sample of children with shared speech and coordination disorders.

These results support the need for a prevalence study on a larger population of children with sCAS in an effort to advance our understanding of the possible shared motor planning deficits between CAS and DCD, which will advance clinical best practice across the pediatric rehabilitation disciplines that specifically work with these children.

Implications

Most often, children who present with possible motor speech delays and disorders are first brought to the attention of S-LPs (Missiuna, Gaines, & Pollock, 2002). Based on the results of this study, it is important that S-LPs be aware of DCD, its prevalence in the general population, and its co-occurrence in children with motor speech disorders (i.e., sCAS or CAS). S-LPs may want to consider using screening tools such as the Little DCDQ-CA or

DCDQ as part of their initial screening protocol for sCAS. In light of the present results, a collaborative, multi-disciplinary (i.e., physical therapy, occupational therapy, speech language pathology, therapy assistant) approach may be particularly important for early identification of DCD and for providing ongoing supports, treatment, and management of children identified as having sCAS and pDCD. Taking a holistic approach to client care is likely to result in gains in multiple motor domains.

Limitations and Future Directions

We have preliminary evidence that there is a co-occurrence between sCAS and pDCD. Because of the small sample size, it will be very important to apply this methodology to a larger population in order to increase statistical power and generalizability. In addition, it would be beneficial for S-LPs to know if there are any particular diagnostic features of sCAS that predict pDCD in order to make more effective clinical decisions regarding client care and to effectively determine when a multidisciplinary approach is needed. Having considered potential characteristics of sCAS and their co-occurrence with pDCD at the outset of the present study, we developed the sCAS checklist. The sCAS checklist used in the present study has not gone through rigorous psychometric development. Ideally, a validated sCAS checklist in combination with clinical impressions would trigger a referral for DCD screening as a best practice process. Further research is needed to validate this checklist as well as explore whether there are characteristics of sCAS that correlate with pDCD and/or predict scores on DCD parent questionnaires. Increased statistical power would also be needed to address these questions.

Another limitation of this pilot study is the use of the Little DCDQ-CA and DCDQ rather than a validated motor assessment along with diagnostic criteria to assess and diagnose DCD. The use of the DSM-5 diagnostic criteria (American Psychiatric Association, 2013), combined with a motor score determined by the application of a validated motor assessment could be used to further support the prevalence of DCD within the sCAS or CAS populations. Moreover, correlates of DCD and physical activity level (e.g., experience and environment) would be strengthened by using quantitative measures of physical activity (e.g., pedometer, fitness tracker) in combination with parent perceptions of activity levels.

Once statistical power has been achieved for this particular method and we have a better understanding of the shared motor deficits between DCD and CAS, translation of this process could take place in the form of training multidisciplinary teams in the context of identification, intervention, management, and support mechanisms, leading to best practice clinical guidelines for this population.

Conclusion

This pilot study was designed to explore the co-occurrence of pDCD in a sample of children with sCAS. Our findings revealed a significant probability that children identified as having sCAS may also have pDCD. These preliminary results have implications for early identification and multidisciplinary involvement to support these children.

This information has the potential to support S-LPs in the management of sCAS, support future recommendations for S-LPs that all children with sCAS should be screened for pDCD, and support a multidisciplinary approach to early identification, intervention to promote lifelong participation, and prevention of secondary consequences. S-LPs who do not work regularly with multidisciplinary team members might consider helping clients pursue other physical therapy and occupational therapy service options as needed. Results of this study may also support the need for tele-practice options when physical therapy and occupational therapy services are not immediately available for families.

The results of this preliminary study could be used to support the need for further research using formal assessment tools and/or validated checklists to examine the prevalence of pDCD in sCAS and even the prevalence of DCD in CAS. In studies with larger sample sizes, the specific sCAS criteria that account for variance in pDCD scores would merit investigation. S-LPs could use this information in screening clients and be diligent in looking for any red flags to necessitate screening for DCD. As a result of the high prevalence of pDCD in the present sample, possible genetic or neurological links between CAS and DCD may also be investigated.

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Appendix

Survey Questions

Suspected Childhood Apraxia of Speech Checklist

Instructions: Please check off the indicators that you observed with each client that made you suspect they had Childhood Apraxia of Speech. You do NOT have to go back and rescreen any clients.

Cluster	*Description*	Check Box if Present or Observed
Cluster 1 Phonological Planning	Inconsistent production of same word	
	Sounds or words may disappear for a period of time during therapy	
	Correct production of a difficult word may occur but cannot be repeated	
	Speech may be "easy" one day and "hard" the next	
	Unusual, idiosyncratic error patterns (sometimes defying transcription!)	
	Increased errors with increased performance load (i.e., repetition of words, especially longer words; words in phrases or sentences)	
	Errors that cannot be explained in terms of common articulation or phonological process errors	
	Poor maintenance of phonotactic structure (permissible syllable structure, consonant clusters, and vowel sequences)	
	Vowel errors (limited repertoire of vowels; less differentiation between vowel productions; vowel errors, especially distortions)	
Cluster 2 Motor programming	Slow diadochokinetic rates	
	Poor sequencing ability of diadochokinetic tasks	
	May have difficulty with volitional nonspeech movements	
	Possible voicing errors	
	Possible resonance inconsistencies	
Cluster 3 Motor planning	Substitutions	
	Deletions	
	Additions	
	Distortions	

	Reversals of sounds in words
	Reversals of syllables in words
	Errors increase or change as number of repetitions increases
	Centralize vowels to "schwa"
	Spontaneous production of phonemes in words but unable to imitate
	Well-rehearsed "automatic" speech is easiest to produce; "on demand" speech is most difficult
	Use of phonemes in words that do not contain that phoneme, but errors on that phoneme in the appropriate context (e.g., "wasi" for "apple" but "bimpoe" for "window")
	Some groping (e.g., trial and error movements on the imitation of single sounds) may be noted
	Prolonged pauses between phonemes, syllables, and words due to challenges with making smooth articulatory transitions from phoneme-to-phoneme or syllable-to-syllable; pauses and breaks between phonemes may give the child's speech a staccato quality
Cluster 4 **Prosodic differences** **No history of babbling**	Rhythm and stress of speech are disrupted
	Apply stress to the wrong syllable of a word
	Use excessive equal stress by applying excessive stress equally to each syllable of a word, giving speech a robotic quality
	Use excessive equal stress on all or most words of a sentence, giving speech a monotone or staccato quality
	Apply stress to an inappropriate lexical item within a sentence
	Overall slow rate
	No history of babbling

Note. Checklist informed by Apraxia Kids (n.d.), American Speech-Language-Hearing Association (2007), Davis and Velleman (2000), Fish (2015), Hall (2000a), Ozanne (2005), and Strand (2017).