



Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Participation of children with developmental coordination disorder

Sara Izadi-Najafabadi^{a,b}, Nikki Ryan^c, Gelareh Ghafooripoor^c, Kamaldeep Gill^{a,b},
Jill G. Zwicker^{b,c,d,e,f,*}



^a Graduate Programs in Rehabilitation Science, University of British Columbia, Vancouver, Canada

^b BC Children's Hospital Research Institute, Vancouver, Canada

^c Department of Occupational Science & Occupational Therapy, University of British Columbia, Vancouver, Canada

^d Department of Pediatrics (Division of Developmental Pediatrics), University of British Columbia, Canada

^e Sunny Hill Health Centre for Children, Vancouver, Canada

^f CanChild Centre for Childhood Disability Research, Hamilton, Canada

ARTICLE INFO

Keywords:

Developmental coordination disorder
Participation
Environment
Home
School
Community

ABSTRACT

Children with developmental coordination disorder (DCD) participate less frequently and in less diverse activities compared to typically-developing children. Participation restrictions have been attributed to poor motor skills, but no studies have examined the influence of the environment on participation of children with DCD. This study examined participation in children with DCD at home, school and in the community, considering both personal and environmental factors.

Eighty-one parents of 4- to 12-year-old children with DCD ($M = 8.3$, $SD = 2.1$) completed the Participation and Environment Measure-Child and Youth (PEM-CY). Our data were compared to previously published data on typically-developing children. Children with DCD participated less frequently than typically-developing children in school and community settings and had less overall environmental support in all three settings. Regarding improvement in participation, children with DCD would benefit from motor interventions that also focus on modification of the environment to support their participation in home, school, and community settings.

What this paper adds

This is the first paper that focuses on the environmental factors associated with decreased participation in children with DCD. The findings in this paper give support to developing interventions for children with DCD that focus on personal and environmental factors to increase participation.

1. Introduction

Participation contributes to child development and quality of life and has been defined as an individual's involvement in life situations (World Health Organization (WHO), 2007). The introduction of the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) attempts to further specify participation to the ever-changing context of a developing child (World Health Organization (WHO), 2007). Children with Developmental Coordination Disorder (DCD) have been shown to participate less frequently and in less diverse activities than typically-developing children (Fong et al., 2011). This includes activities of daily living (ADL) (Van der Linde et al., 2015), out of school activities (Jarus, Lourie-Gelberg, Engel-Yeger, & Bart, 2011), and

* Corresponding author at: BC Children's Hospital Research Institute, K3-180, 4480 Oak Street, Vancouver, BC, V6H 3V5, Canada.
E-mail address: jill.zwicker@ubc.ca (J.G. Zwicker).

<https://doi.org/10.1016/j.ridd.2018.05.011>

Received 30 August 2017; Received in revised form 30 April 2018; Accepted 20 May 2018
Available online 02 July 2018

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social participation (Sylvestre, Nadeau, Charron, Larose, & Lepage, 2013). A systematic review of activities and participation in children with DCD concluded that previous studies have focused mainly on issues with body functions and structures, most frequently motor impairment, with only a small percentage focusing on participation limitations (Magalhães, Cardoso, & Missiuna, 2011).

DCD is defined as a distinct motor disorder, which is categorized under a broader heading of neurodevelopmental disorders in the DSM-5 (American Psychiatric Association, 2013). It is characterized by marked impairment in motor coordination for the child's age and opportunity for learning (American Psychiatric Association, 2013). The deficits children with DCD experience cannot be attributed to intellectual disability, visual impairment or neurological conditions that affect motor skills (American Psychiatric Association, 2013). DCD does not have a single presentation, as fine motor skills and/or gross motor skills can be affected (Visser, 2003; Zwicker, Missiuna, Harris, & Boyd, 2012). Children with DCD are frequently thought to be “clumsy” and experience difficulty performing their ADL. This could be attributed to their slowness and inaccurate performance of motor activities, such as handwriting and participating in sports (American Psychiatric Association, 2013). Delays in motor learning are associated with poor performance, which in turn leads to a decrease in participation in ADL in children with DCD (Van der Linde et al., 2015). These difficulties contribute to depression, social isolation, motor activity avoidance, as well as low levels of physical activity participation in adulthood (Rasmussen & Gillberg, 2000; Mandich, Polatajko, & Rodger, 2003). Children with DCD participate less frequently in organized recreational and physical activities and spend more time performing activities individually than typically-developing children (Christiansen, 2000; Poulsen, Ziviani, Cuskelly, & Smith, 2007; Poulsen, Ziviani, & Cuskelly, 2008; Zwicker, Harris, & Klassen, 2013). DCD influences multiple domains of quality of life (QOL) including physical, psychological and social functioning (Zwicker et al., 2013).

Environmental factors, which include the physical, social and attitudinal environments, influence a person's functioning in their daily life (World Health Organization (WHO), 2007). Participation levels of children with disabilities are also influenced by these environments (Colver et al., 2012; Coster et al., 2011; Harding et al., 2009); children with disabilities participate and enjoy an activity when its setting provides physical and social supports and they feel connected to their environment (Coster et al., 2011; Harding et al., 2009). Moreover, participation of children with disabilities, specifically cerebral palsy, in their social roles is associated with a supportive attitudinal environment (e.g., more favorable attitudes of family, friends, teachers, therapists, and classmates) (Colver et al., 2012). There have been no studies that focus on environmental factors associated with decreased participation in children with DCD (Magalhães et al., 2011). The purpose of this study was to examine the participation in children with DCD at home, school and in the community, considering both personal and environmental factors. In addition, predictors of participation in children with DCD were examined. We hypothesized that children with DCD would have lower participation frequency and involvement compared to published data on typically-developing children. We also expected that environmental factors would play a role in the level and quality of participation among children with DCD. The outcomes will help us discover what environmental factors, barriers and supports, influence participation in children with DCD, which in turn will aid us to focus efforts to improve quality of life and increase participation in different settings.

2. Methods

A cross-sectional study design was used to describe the participation of children with DCD and to identify environmental factors that influence participation. His study was approved by the Children's and Women's Health Centre/University of British Columbia Clinical Research Ethics Board.

2.1. Participants

Using a sample of convenience, 85 children with DCD aged 4–12 years were diagnosed and screened through the DCD Research Clinic at Sunny Hill Health Centre for Children from January 2014 to September 2016. Parents of 81 children (95%) with DCD consented to participate and completed the study. Children were included if they had a diagnosis of DCD in accordance with the 5th Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) criteria (American Psychiatric Association, 2013) and European Academy of Childhood Disability guidelines (Blank et al., 2012), as assessed by a developmental pediatrician and an occupational therapist. We used a score of ≤ 16 th percentile on the Movement Assessment Battery for Children-2 Test (MABC-2; Henderson, Sugden, & Barnett, 2007) (except for the three 4 year olds and eight 5 year olds, where we used ≤ 5 th percentile) and a score in the indicative or suspected range on the Developmental Coordination Disorder Questionnaire (DCDQ; Wilson, Kaplan, Crawford, & Roberts, 2007) to inform diagnosis. MABC-2 is a standardized assessment to identify motor impairments of children and adolescents from 3 to 16 years of age. It consists of three components of to assess manual dexterity (3 tasks), aiming & catching (2 tasks), and balance (3 tasks); a total score is derived from the result from all three components and was used in this study (Henderson et al., 2007). DCDQ is a parent-report questionnaire which requires parents to compare their child's motor coordination with their peers in order to identify motor problems (Wilson et al., 2007). We also assessed children's attention using the parent form of the Conner's ADHD Index (Conners, 2009) and estimated IQ using the Kaufman Brief Intelligence Test-2nd edition (KBIT-2; Kaufman & Kaufman, 2004). Because of high comorbidity of DCD with other neurodevelopmental disorders (e.g., Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorders, and Learning Disabilities), children who manifested comorbidities were also included. As per DSM-5 diagnostic criteria for DCD (American Psychiatric Association, 2013), children were excluded if diagnosed with other movement conditions (e.g., cerebral palsy, muscular dystrophy) or intellectual disability. Table 1 illustrates demographics of our participants.

Table 1
Clinical Characteristics of Children with Developmental Coordination Disorder.

Clinical Variables	Mean (SD) OR N (%)
Male sex	68 (84)
Age (years)	8.3 (2.1)
MABC-2 (percentile)	3.4 (4.7)
DCDQ (# in suspected or indicative range)	79 (98)
KBIT-2 (standard score)	103 (13.2)
Conners ADHD Index (t-score)	87 (8.8)
Co-occurring conditions (definitive or probable diagnosis)	
Attention Deficit Hyperactivity Disorder	54 (67)
Autism Spectrum Disorder	7 (9)
Learning Disabilities	40 (49)
Anxiety	35 (43)

ADHD, Attention Deficit Hyperactivity Disorder; DCDQ, Developmental Coordination Disorder Questionnaire; KBIT-2, Kaufman Brief Intelligence Test-2nd edition; MABC-2, Movement Assessment Battery for Children-2nd edition.

2.2. Procedure

Participants attending the DCD Clinic were assessed using the DCDQ and MABC-2. If parents (as well as children 8 years and older) provided written consent (assent) to take part in this study, the KBIT-2 was also administered and the Conner's ADHD Index and Participation and Environment Measure - Children and Youth (PEM-CY) were completed by parents. Parents needed to be able to read and comprehend English to complete the questionnaires. A research assistant provided the parents with a paper copy of the PEM-CY while attending the DCD Clinic to complete during their visit. Sixty-four mothers, 13 fathers, three legal guardians, and one step-father of children with DCD completed the PEM-CY. Data were also collected on family demographics, including partial postal code and maternal education, which were used as proxies for socioeconomic status.

2.3. Participation and environment measure-children and youth (PEM-CY)

Parents filled out the PEM-CY, which is a parent-report measure that investigates how environmental factors influence (facilitate or hinder) participation within a child's home, school, and community settings (Coster et al., 2013). This measure has moderate to good internal consistency, as well as good test-retest reliability (Coster et al., 2011). The PEM-CY collects data regarding *participation*—the extent to which young individuals with and without disabilities participate in important activities—and *environmental factors*—the extent to which particular features of the environment are perceived to be supporting or challenging the young individual's participation—in child's home, school, and community settings. Regarding *participation*, items for each setting represent types of activities usually performed in that specific setting and it contains a list of 25 items, which includes 10 items about home participation (e.g., watching TV, videos, and DVDs), five items about school participation (e.g., field trips, school events, and special roles at school), and 10 items about community participation (e.g., neighborhood outing). For each item/activity type, parents are asked to determine how frequently the child has participated (*participation frequency*) in an activity over the past four months; how involved the child typically is while participating (*participation involvement*); and whether the parent would like to see the child's participation in this type of activity change (*desire for change*). Then, for *environmental factors*, parents are asked whether certain features of the environment facilitate or make it more challenging for their child to participate in activities of that setting. There are seven items for home (e.g., relationships with family members), nine items for school (e.g., attitude of teachers, the safety of the school), and nine items community (e.g., outside weather conditions) settings. Accordingly, environmental resources, supports,

Table 2
PEM-CY variables.

Variable	Description
Participation frequency	An 8-point Likert scale, from never (0) to daily (7)
Participation involvement	A 5-point scale, from minimally involved (1) to very involved (5)
Desire for change	A percentage of activities that parents want to see change in per setting, where a higher percentage indirectly indicates less satisfaction with the child's participation
Number of activities	Sum of all of the activities that the child participates in per setting
Environmental resources	A 3-point rating scale of usually no (1), sometimes yes/sometimes no (2), and usually yes and not needed (3)
Environmental supports	Sum of the number of items a parent responded, "usually helps" or "usually yes".
Environmental barriers	Sum of the number of items a parent responded, "usually makes harder" or "usually no"
Environmental helpfulness	A 3-point rating scale of usually makes harder (1), sometimes helps/ sometimes makes harder (2), and usually helps and not an issue (3)
Overall environmental support	Sum of the "environmental helpfulness" and "environmental resources" variables within a setting

barriers, helpfulness and overall environmental support can be calculated (Coster et al., 2011). Table 2 provides a brief description for all mentioned variables.

The PEM-CY has moderate to good test-retest reliability over 4 weeks as well as moderate to good internal consistency for Frequency, Involvement, Environmental Supportiveness and Environmental Resources scales, ranging from 0.59 (Home Frequency) to 0.83 (Home Involvement). PEM-CY is a valid measure to discriminate between children and youth with and without disabilities (e.g., neurodevelopmental disabilities) (Coster et al., 2011).

2.4. Data analysis

The PEM-CY has published data (means, SD) for up to 294 children without a disability (145 male, 149 female) age 5–17 years old, from Canada and the United States (Coster et al., 2014). We applied unpaired t-tests to compare our data on children with DCD with published data for up to 183 children without a disability ≤ 12 years of age. These data are not normative data but are for comparative purposes for the following variables: participation frequency, participation involvement, number of activities, environmental barriers, environmental supports, environmental resources, environmental helpfulness, overall environmental support, as well as percentage of children who never participated in the listed activities in each setting. To correct for multiple comparisons across all three settings, Bonferroni correction was used. We also calculated effect sizes as defined by Cohen (1988) as an indication of clinical significance (Page, 2014). We employed Linear Regression Models to identify predictors of home, school, and community participation amongst the following independent variables: sex, age, MABC-2 scores, DCDQ, income category, and maternal education. Neighbourhood in which the family resided was determined using the first three digits of the participants' postal codes and then further categorized into average household income categories using 2011 Statistics Canada Census data. To avoid multicollinearity, the degree of independence among independent variables was checked. We also conducted model diagnostic tests to ensure that the models fit the data well.

3. Results

3.1. Participation

Table 3 summarizes the mean and standard deviation of participation-related variables in children with DCD compared to typically-developing children. Table 4 indicates the percentages of participants that responded “Never participate”.

3.1.1. Home

While there were no significant differences in participation frequency and the number of activities performed at home between the two groups (see Table 3), children with DCD showed significantly lower participation involvement at home compared to typically-developing children ($t(262) = 2.6, p = .005$). Approximately 68.8% of parents showed desire for change in the child's participation in activity usually performed at home. The percentage of children with DCD that never participated in homework, school preparation and socializing using technology in the home environment was significantly lower than peers ($p < .0001$) (see Table 4).

Table 3
Participation Frequency and Involvement (n = 81).

Setting	DCD Mean (SD)	TD Mean (SD)	P-value	Cohen's d
Participation Frequency				
Home	5.8 (0.7)	5.7 (1.1)	0.58	0.10
School	3.8 (1.1)	5.0 (0.8)	< 0.0001 [*]	1.25
Community (n = 80)	3.0 (0.8)	4.5 (0.7)	< 0.0001 [†]	1.99
Participation Involvement				
Home (n = 79)	3.7 (0.5)	3.9 (0.5)	0.005 [*]	0.40
School (n = 79)	3.6 (0.8)	4.3 (0.7)	< 0.0001 [†]	0.93
Community (n = 79)	3.7 (0.7)	4.2 (0.6)	< 0.0001 [†]	0.77
Desire for Change				
Home (n = 80)	68.8 (20.6)	NA	NA	
School (n = 78)	63.6 (31.6)	NA	NA	
Community (n = 80)	57.8 (27.7)	NA	NA	
Number of activities				
Home	9.4 (0.9)	9.3 (1.6)	0.83	0.08
School	3.7 (0.9)	4.0 (0.9)	0.06	0.33
Community	6.7 (1.7)	7.4 (1.5)	0.003 [†]	0.44

DCD, developmental coordination disorder; NA, not available; TD, typically-developing children.

Cohen's d effect sizes: 0.2 small, 0.5 medium, 0.8 large (Cohen, 1988).

* $p < 0.017$ is significant after Bonferroni correction.

Table 4
“Never Participates” in specified activities in home, school, and community.

Settings	DCD (%)	TD (%)	P-value
Home			
Watching TV, videos, and DVDs	0	0	> 0.99
Getting together with other people	0	0	> 0.99
Personal Care Management	1.2	0	0.06
Arts, crafts, music, and hobbies	0	0.3	0.62
Computer and video games	4.9	0.7	0.008
Homework	8.9	1.0	< 0.0001*
Household chores	2.5	1.4	0.49
Indoor play and games	1.3	2.4	0.55
School preparation	19.8	3.4	< 0.0001*
Socializing using technology	30.0	9.2	< 0.0001*
School			
Classroom activities	1.3	0	0.05
Field trips and school events	3.8	1.0	0.08
Getting together with peers outside of class	3.8	1.0	0.08
School-sponsored teams, clubs, and organizations	53.8	27.6	< 0.0001*
Special roles at school	53.3	43.2	0.11
Community			
Neighbourhood outings	0	0.3	0.62
Unstructured physical activities	1.3	1.7	0.80
Getting together with children in community	15.4	2.7	< 0.0001*
Community events	7.5	4.1	0.21
Organized physical activities	21.3	8.2	< 0.0009*
Overnight visits or trips	20.3	12.6	0.08
Classes and lessons	45.0	34.7	0.09
Organizations, groups, clubs, or leadership activities	73.1	36.1	< 0.0001*
Religious or spiritual gatherings/activities	60.8	51.0	0.12
Working for pay	68.8	52.4	0.009

DCD, developmental coordination disorder; TD, typically-developing children.

* $p < 0.003$ is significant after Bonferroni correction.

3.1.2. School

Significant differences were found between children with DCD and typically-developing children in participation frequency ($t(247) = 10.12, p < .0001$) and participation involvement ($t(248) = 6.5, p < .0001$) (see Table 3). Approximately 63.6% of parents showed desire for change in the child's participation in activity usually performed at school. There were no significant differences found in number of activities performed between children with DCD and typically-developing children (see Table 3). However, significantly more children with DCD (greater than half) had never participated in school-sponsored teams, clubs and organizations, compared to a quarter of typically-developing children (see Table 4).

3.1.3. Community

All participation-related variables in community settings, including participation frequency ($t(236) = 16.2, p < .0001$), participation involvement ($t(236) = 6.2, p < .0001$) and the number of activities performed ($t(236) = 3.0, p < .0001$) were significantly lower in children with DCD compared to typically-developing children (see Table 3). Approximately 57.8% of parents showed desire for change in the child's participation in activity usually performed in the community. Significantly more children with DCD than typically-developing children had never participated in getting together with children in the community, organized physical activities, and community organizations, groups, clubs, or leadership activities (see Table 4).

3.2. Environmental factors

Table 5 illustrates environmental factors in children with DCD and typically-developing children in three settings of home, school, and community.

3.2.1. Home

While there was no significant difference between the use of environmental resources in children with DCD and typically-developing children, significant differences were found in environmental supports ($t(373) = 3.5, p = .0006$), environmental barriers ($t(373) = 5.4, p < .0001$), environmental helpfulness ($t(373) = 6.6, p < .0001$), and overall environmental support ($t(373) = 5.3, p < .0001$). Parents reported that the physical (18.8%) and cognitive demands (22.8%) of activities at home were the greatest environmental barriers to participation in children with DCD. In contrast, parents reported adequate support at home in regard to supplies in the home (80.0%), information (69.6%), time (47.5%), and money (56.3%).

Table 5
Environmental Factors related to Participation (n = 81).

	DCD Mean (SD)	TD Mean (SD)	P-value	Cohen's d
Environmental Resources				
Home (n = 80)	87.2 (13.2)	90.4 (12.0)	0.04	0.25
School (n = 80)	88.2 (11.0)	93.2 (8.7)	< 0.0001*	0.50
Community	87.6 (13.2)	92.3 (9.2)	0.0004*	0.41
Environmental Supports				
Home	32.2 (17.6)	25.8 (14.0)	0.0006*	0.40
School	32.8 (15.4)	36.0 (13.4)	0.07	0.22
Community	31.0 (17.0)	34.4 (14.0)	0.07	0.22
Environmental Barriers				
Home	8.0 (10.5)	2.9 (6.5)	< 0.0001*	0.58
School	12.3 (11.7)	3.8 (7.6)	< 0.0001*	0.86
Community	10.5 (14.5)	3.4 (7.1)	< 0.0001*	0.62
Environmental Helpfulness				
Home	84.9 (11.5)	92.5 (8.4)	< 0.0001*	0.75
School (n = 80)	77.7 (11.2)	91.4 (9.7)	< 0.0001*	1.31
Community	79.5 (13.3)	93.5 (8.8)	< 0.0001*	1.25
Overall Environmental Support				
Home	85.9 (9.8)	91.7 (8.3)	< 0.0001*	0.64
School (n = 80)	82.6 (9.4)	92.3 (7.6)	< 0.0001*	1.14
Community	83.1 (11.2)	93.0 (7.4)	< 0.0001*	1.04

DCD, developmental coordination disorder; TD, typically-developing children.

Cohen's d effect sizes: 0.2 small, 0.5 medium, 0.8 large (Cohen, 1988).

* $p < 0.003$ is significant after Bonferroni correction.

3.2.2. School

There were significant differences found in environmental resources ($t(346) = 4.2, p < .0001$), environmental barriers ($t(346) = 7.6, p < .0001$), environmental helpfulness ($t(346) = 10.8, p < .0001$) and overall environmental support ($t(346) = 9.5, p < .0001$) between children with DCD and typically-developing group, but there was no significant difference found in environmental supports between the two groups. Parents reported that the sensory qualities of the school environment (e.g., amount and/or type of sound, light, temperature, textures of objects) (31.6%), as well as the physical (36.3%), cognitive (51.9%), and social (27.5%) demands of activities at school were the greatest environmental barriers to participation in children with DCD. In contrast, parents reported adequate support at school with regard to attitudes and actions of teachers, coaches, or staff (46.3%), personal transportation (60.8%), programs and services (39.2%), school-related policies and procedures (40.3%), supplies (68.8%), information (61.3%), time (60.0%), and money (67.5%).

3.2.3. Community

There was no significant difference found in environmental supports while there were significant differences in environmental resources ($t(331) = 3.6, p = .0004$), environmental barriers ($t(331) = 5.9, p < .0001$), environmental helpfulness ($t(331) = 10.9, p < .0001$) and overall environmental support ($t(331) = 9.2, p < .0001$). Parents reported that the physical (22.2%), cognitive (25.9%), and social (18.5%) demands of the activities and programs and services (19.8%) in the community were the greatest environmental barriers to participation in children with DCD. In contrast, parents reported relatively more support in the community for personal transportation (64.2%), public transportation (38.3%), programs and services (43.2%), information (70.0%), equipment or supplies (65.0%), time (56.3%), and money (57.5%).

3.3. Participation predictors

Table 6 shows all the coefficients and corresponding p-values for various variables used in linear regression analysis.

3.3.1. Home

DCDQ total score ($\beta = .02, t(71) = 3.5, p = .0008$) and the child's age ($\beta = -.06, t(71) = -2.2, p = .03$) significantly predicted average home participation. As a whole, this model explained a significant proportion of variance in average home participation (Adjusted $R^2 = 0.27, F(6,71) = 5.65, p < .001$). Sex, MABC-2, income and maternal education did not significantly predict average home participation.

3.3.2. School

DCDQ total score significantly predicted average school participation ($\beta = .03, t(71) = 2.84, p = .006$). As a whole, this model explained a significant proportion of variance in average school participation (Adjusted $R^2 = .11, F(6,71) = 2.64, p < .05$). Sex, age, MABC-2, income and maternal education did not significantly predict average school participation.

Table 6
Predictors of Participation in Children with Developmental Coordination Disorder.

Clinical Variable	Home		School		Community	
	Co-efficient (SE)	P-value	Co-efficient (SE)	P-value	Co-efficient (SE)	P-value
Age	−0.06 (0.03)	0.03	−0.05 (0.05)	0.30	−0.02 (0.04)	0.59
Sex	0.14 (0.14)	0.32	0.15 (0.24)	0.56	0.07 (0.20)	0.73
DCDQ	0.02 (0.01)	0.0008*	0.03 (0.01)	0.006*	0.03 (0.01)	0.001†
MABC-2	0.02 (0.03)	0.55	0.02 (0.06)	0.73	0.01 (0.05)	0.88
Income	−0.02 (0.09)	0.84	0.11 (0.14)	0.44	−0.06 (0.12)	0.62
Maternal Education	0.04 (0.04)	0.22	0.02 (0.06)	0.77	0.03 (0.05)	0.62

DCDQ, Developmental Coordination Disorder Questionnaire; MABC-2, Movement Assessment Battery for Children-2nd edition.

* $p < 0.017$ is significant after Bonferroni correction.

3.3.3. Community

DCDQ total score significantly predicted average community participation ($\beta = 0.03$, $t(71) = 3.34$, $p = .001$). As a whole this model explained a significant proportion of variance in average community participation, Adjusted $R^2 = .13$, $F(6,71) = 2.9$, $p < .05$. Sex, age, MABC-2, income and maternal education did not significantly predict average community participation.

4. Discussion

4.1. Participation patterns in children with DCD

The findings from this study indicate significant differences across all three settings in the participation of children with DCD when compared to typically-developing children. Children with DCD participate less frequently in school and community settings, but there is no difference in their participation frequency at home. Children with DCD tend to choose activities that are less socially engaging and quieter (Jarus et al., 2011; Poulsen et al., 2007). The fact that at-home activities (e.g., watching TV, computer game, art, personal management care) are usually done solo can explain why children with DCD participate as much as typically-developing children at home. Moreover, family members may provide a safe environment for children and they usually compensate for their difficulties. This motivates children to engage in activities at home more frequently. Interestingly, a significantly higher percentage of children with DCD than typically-developing children never participate in socializing using technology. This finding is concerning, as children with DCD also appear to be missing out on socializing by texting and through social media, a dominant form of socializing for today's youth.

Compared to typically-developing children, children with DCD participated in fewer numbers of activities in the community setting. This could be indicative of less opportunities for participation and less overall environmental support, and that more team/group based activities are being offered in the community. In general, as a child grows, they shift from home-based activities towards community activities; however, children with disability (e.g., cerebral palsy) usually experience difficulties with this transition and engage in fewer activities outside the home relative to their peers (Engel-Yeger, Jarus, Anaby, & Law, 2009). This may explain our findings that children with DCD are involved in the same number of activities as their peers at home and school, while they have less activity diversity in community. This result is in line with previous findings on limited participation diversity in children with DCD (Fong et al., 2011; Jarus et al., 2011); these studies don't specify difference in number of activities in each setting but they mentioned that the number of informal, physical, social, skill-based activities, as well as self-improvement activities are fewer in children with DCD compared to controls. However, Liberman, Ratzon, and Bart, 2013 studied participation in younger children with DCD (age range 5–6.11 years) where they did not find a difference in diversity and frequency of activities in which they participate. They reasoned that younger children still need parents' assistance to perform activities and that parents are responsible for participation frequency.

Another important finding regarding participation patterns in children with DCD refers to significantly decreased involvement at home, school, and community in children with DCD. This indicates that even if children with DCD take part in a similar range of home activities as typically-developing children, their involvement in the activities is to a lesser degree. This may relate to their dependency to others, especially their parents, to perform activities at home.

Parents' desire for change in the participation of children with DCD was high in all three settings, indicating that many parents are not satisfied and want a change in their child's participation. This opens a window to occupational therapists and the areas on which they should focus—participation in this population—as per client-centred practice. The desire for change is negatively associated with the environmental supportiveness in each setting, meaning that the less the support, the less parents are satisfied, and the more desire for change they report (Coster et al., 2011). Additionally, teenagers with DCD have a desire for being more physically active and to participate in more activities (Barnett, Dawes, & Wilmut, 2013). As such, supporting children to engage in the activities in which they would like to participate should be considered as a key element on which to focus treatment of children with DCD.

4.2. Environmental factors and participation in children with DCD

Our results revealed the effect of environmental factors on participation in children with DCD for the first time. In all three settings, parents of children with DCD reported more environmental barriers, less environmental helpfulness, and less overall environmental support than typically-developing children. Environmental factors have recently received a lot of attention regarding their role in participation of children with neurodevelopmental disorders with the introduction of the ICF, depicting participation as associated with personal factors (e.g., age and gender) and environmental factors (e.g., accessibility, supportiveness, socioeconomic status) (World Health Organization (WHO), 2007). Studies have shown that environmental factors such as socio-economic status, mother's education, and maternal self-efficacy can explain participation above and beyond personal factors in children with mild motor disabilities (Soref et al., 2012). This finding opens a new window to DCD intervention that can be evaluated and targeted in clinical settings.

In our study, across all three settings, parents reported the physical demands (e.g., strength, endurance, coordination) of the activities to be one of the greatest barriers to participation. Given the striking relationship of participation with motor ability in this population (Fong et al., 2011), it was expected that parents mark physical demands as the greatest barrier to participation. As physical demands continue to be a barrier to participation in children with DCD, programs and services offered in all settings are not sufficient to support the unique needs of these children. In line with our findings, a qualitative study of constraints and facilitators to participation reported that teenagers with DCD perceive poor motor skills, fatigue, and lack of motivation as internal constraints to participation (Barnett et al., 2013).

Parents of children with DCD report more environmental supports in the home and no difference in perceived environmental resources, which could account for the similarities in participation between the two groups at home. Perceived high environmental support at home and not the other two settings can be due to parents' evident role and support at home. This confirms our earlier claim that children with DCD more frequently engage in home-based activities because it is a safe and supported environment where family members compensate for their problems and increase the chance of accomplishment. For children with mild motor disabilities, an environmental factor which determines the quality of the physical and emotional environment to promote participation is maternal self-efficacy (Soref et al., 2012). Teenagers with DCD perceive lack of understanding of DCD from peers and teachers as well as difficulty traveling to activities as external constraints to participation (Barnett et al., 2013). Taken together, given the importance of environmental supports, as clinicians, we have to ensure that children with DCD receive enough supports in other settings.

The second most commonly reported barrier was cognitive demands of the activities across all settings. Mandich, Polatajko, Missiuna, and Miller, 2001 highlighted the importance of cognitive demands of the activities in a study of Cognitive Orientation to Daily Occupational Performance (CO-OP). They showed that children with DCD do not have adequate task knowledge to support task performance. CO-OP is one of the most beneficial interventions for the motor performance of children with DCD that covers this barrier through a cognitive-based, problem-solving approach that uses verbal mediation and identifies cognitive strategies to influence motor skill acquisition and occupational performance (Smiths-Engelsman et al., 2013). For example, one of the domain specific strategies of CO-OP is supplementing task knowledge (Mandich et al., 2001). CO-OP has shown to improve impairment, activity, and participation in this population (Thornton et al., 2016).

Social demands of activities at school and in the community were also found to be barriers of participation among children with DCD. This is consistent with findings that children with DCD spend more time performing activities on their own as opposed to in groups (Jarus et al., 2011; Poulsen et al., 2007). Thus, clinicians who work with children with DCD need to target social demands of environment as a treatment goal and ensure there is an adequate fit between the person, the task, and the environment. Poulsen et al. (2007) reported that team sports can act as a mediator between physical coordination ability and loneliness in boys with DCD. CO-OP has also shown potential as a group therapy to develop sense of belonging, socialization, and self-confidence in this population (Anderson, Wilson, & Williams, 2017).

In addition, children with DCD had less environmental resources such as time and money allocated in school and community settings than typically-developing children. For example, at school, teachers are limited by funding and therefore may not be able to provide as much support as may be necessary to children with DCD; there may also be one teacher to many children. Alternatively, at home there is more one to one support provided by parents and guardians. Therefore, clinicians should focus interventions in school and community settings to have the greatest impact on participation of children with DCD in settings that are most affected.

At present, the lack of programs well suited for children with DCD may be due to programs being designed for children with more severe physical disabilities. Previous studies have noted some promising interventions for children with DCD in the community. Zwicker et al. (2015) found that parents and children reported benefits, such as the confidence to try new activities, at a camp specifically created for the needs of children with DCD. As improving self-efficacy with regard to motor tasks has been found to be an important factor in improving participation in children with DCD and reducing activity limitations, health professionals should focus on developing similar programs based in school and the community (Missiuna, Rivard, & Bartlett, 2006; Zwicker et al., 2015). Interventions for children with DCD have traditionally focused on addressing personal factors only (Smiths-Engelsman et al., 2013). The findings in this study demonstrate that more focus should be placed on addressing environmental factors in addition to personal factors to increase participation in children with DCD. Interventions should also encompass adaptations in the environment to support participation of children with DCD in home, school, and community settings. Ecological intervention is an effective therapeutic approach for children with DCD that considers the role of environmental factors in participation (Henderson & Sugden, 2007; Chamber & Sugden, 2016). It incorporates principles of the cognitive motor approach in a more family, community, and ecological setting with the goal of life-long participation (Henderson & Sugden, 2007). Future research could further examine the specific environmental factors that influence participation in children with DCD, including barriers and supports in the environment.

4.3. Determinants of participation in children with DCD

Consistent with Jarus et al. (2011) and Fong et al. (2011), who reported motor ability to be positively correlated with participation, our study confirmed that motor ability/difficulties screened through the DCDQ was a predictor of participation in children with DCD across all settings, which indicates that motor function is a significant predictor of participation. Thus, continued effort to improve functional motor skills of children with DCD (as opposed to addressing underlying motor impairments) are more likely to affect participation (Missiuna et al., 2006).

5. Limitations

Partial postal codes were used as a proxy to determine average household income for each neighbourhood in which participants reside. Therefore, although income was not found to be a predictor of participation in this study, the data may not have been representative of each participant's true household income. However, the data did show a range of household incomes, with most families falling in the middle income range.

The relationship between DCDQ scores and participation may be a reflection of both measures being parent report; it should be noted that children's perspectives and values are also essential to conclusively decide on their participation limitations and, consequently, to make meaningful and long-term changes (Granlund et al., 2012; Maxwell, Augustine, & Granlund, 2012). In future studies, the children's perspective should be considered. Another limitation of this study was lack of information on the typically-developing group and uncertainty of them being matched to our studied group. Other possible predictors, such as self-efficacy, were not collected.

6. Conclusion

Children with DCD participate less frequently than typically-developing children in school and community settings, and although they participate the same amount as their peers at home, their level of engagement is still significantly less. Further, in all three settings, a majority of parents report a desire for change in the level of participation of their children in activities at home, school, and community. Furthermore, motor function was the primary predictor of participation in children with DCD. Therefore, children with DCD would benefit most from motor interventions with a focus on increasing functional motor skills and participation. In addition to addressing motor skills, our study highlights that intervention also needs to address environmental barriers to participation of children with DCD.

Conflicts of interest

The authors have no conflicts of interest to declare.

Acknowledgements

We are grateful to the children and families who participated in this research. We also thank Dr. Elizabeth Mickelson for assessing and diagnosing the children with DCD, as well as Jane Shen, Sara Leckie, and Janet Rigney for collecting and managing the data. Sara Izadi-Najafabadi is funded by Brain Canada/Kids Brain Health Network and Kamaldeep Gill is funded by Canadian Institute for Health Research. Dr. Zwicker is funded by the Michael Smith Foundation for Health Research, Canadian Child Health Clinician Scientist Program, BC Children's Hospital Research Institute, Sunny Hill Foundation, and Canadian Institute for Health Research.

References

- American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, DC: American Psychiatric Association.
- Anderson, L., Wilson, J., & Williams, G. (2017). Cognitive orientation to daily occupational performance (CO-OP) as group therapy for children living with motor coordination difficulties: An integrated literature review. *Australian Occupational Therapy Journal*, *64*, 170–184. <http://dx.doi.org/10.1111/1440-1630.12333>.
- Barnett, A. L., Dawes, H., & Wilmut, K. (2013). Constraints and facilitators to participation in physical activity in teenagers with Developmental Co-ordination Disorder: An exploratory interview study. *Child: Care, Health and Development*, *39*, 393–403.
- Chamber, M. E., & Sugden, D. A. (2016). Intervention for young children displaying coordination disorders. *Journal of Early Childhood Research*, *14*, 115–131.
- Christiansen, A. S. (2000). Persisting motor control problems in 11- to 12-year-old boys previously diagnosed with deficits in attention, motor control and perception (DAMP). *Developmental Medicine & Child Neurology*, *42*, 4–7. <http://dx.doi.org/10.1111/j.1469-8749.2000.tb00017.x>.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. New York, NY: Routledge Academic.
- Colver, A., Thyen, U., Arnaud, C., Beckung, E., Fauconnier, J., Marcelli, M., et al. (2012). Association between participation in life situations of children with cerebral palsy and their physical, social, and attitudinal environment: A cross-sectional multicenter European study. *Archives of Physical Medicine and Rehabilitation*, *93*, 2154–2164.
- Conners, C. K. (2009). *Conners 3rd edition (Conners 3)*. Toronto, ON: Multi-Health Systems.
- Coster, W., Bedell, G., Law, M., Khetani, M. A., Teplicky, R., Liljenquist, K., et al. (2011). Psychometric evaluation of the participation and environment measure for children and youth. *Developmental Medicine & Child Neurology*, *53*, 1030–1037. <http://dx.doi.org/10.1111/j.1469-8749.2011.04094>.
- Coster, W., Law, M., Bedell, G., Anaby, D., Khetani, M., & Teplicky, R. (2014). *Participation and environment measure for children and youth (PEM-CY) user's guide*. Available from: <http://canchild.ca/en/resourcesGeneral/TermsOfUse.pdf>.
- Coster, W., Law, M., Bedell, G., Liljenquist, K., Kao, Y., Khetani, M., et al. (2013). School participation, supports and barriers of students with and without disabilities. *Child: Care, Health and Development*, *39*, 535–543. <http://dx.doi.org/10.1111/cch.12046>.
- Engel-Yeger, B., Jarus, T., Anaby, D., & Law, M. (2009). Differences in patterns of participation between youths with cerebral palsy and typically-developing peers.

- American Journal of Occupational Therapy*, 63(1), 96–104.
- Fong, S. S. M., Lee, V. Y. L., Chan, N. N. C., Chan, R. S. H., Chak, W., & Pang, M. Y. C. (2011). Motor ability and weight status are determinants of out-of-school activity participation for children with developmental coordination disorder. *Research in Developmental Disabilities*, 32, 2614–2623. <http://dx.doi.org/10.1016/j.ridd.2011.06.013>.
- Granlund, M., Arvidsson, P., Niia, A., Björck-Åkesson, E., Simeonsson, R., & ...Pless, M. (2012). Differentiating activity and participation of children and youth with Disability in Sweden: A third qualifier in the International Classification of Functioning, Disability, and Health for children and youth? *American Journal of Physical Medicine and Rehabilitation*, 91, S84–S96.
- Harding, J., Harding, K., Jamieson, P., Mullally, M., Politi, C., Wong-Sing, E., et al. (2009). Children with disabilities' perceptions of activity participation and environments: A pilot study. *Canadian Journal of Occupational Therapy*, 76, 133–144.
- Henderson, S. E., & Sugden, D. A. (2007). *Ecological intervention for children with movement difficulties*. London: Harcourt.
- Henderson, S. E., Sugden, D. A., & Barnett, A. (2007). *Movement assessment Battery for children (MABC-2)* (2nd ed.). London: Harcourt.
- Jarus, T., Lourie-Gelberg, Y., Engel-Yeger, B., & Bart, O. (2011). Participation patterns of school-aged children with and without DCD. *Research in Developmental Disabilities*, 32, 1323–1331. <http://dx.doi.org/10.1016/j.ridd.2011.01.033>.
- Kaufman, A. S., & Kaufman, N. L. (2004). *K-BIT2: Kaufman brief intelligence test* (2nd ed.). Circle Pines: AGS Publishing.
- Liberman, L., Ratzon, N., & Bart, O. (2013). The profile of performance skills and emotional factors in the context of participation among young children with Developmental Coordination Disorder. *Research in Developmental Disabilities*, 34(1), 87–94.
- Magalhães, L. C., Cardoso, A. A., & Missiuna, C. (2011). Activities and participation in children with developmental coordination disorder: A systematic review. *Research in Developmental Disabilities*, 32, 1309–1316. <http://dx.doi.org/10.1016/j.ridd.2011.01.029>.
- Mandich, A., Polatajko, H., Missiuna, C., & Miller, L. (2001). Cognitive strategies and motor performance in children with developmental coordination disorder. *Physical & Occupational Therapy in Pediatrics*, 20(2), 125–143. http://dx.doi.org/10.1300/J006v20n02_08.
- Mandich, A. D., Polatajko, H. J., & Rodger, S. (2003). Rites of passage: Understanding participation of children with developmental coordination disorder. *Human Movement Science*, 22, 583–595. <http://dx.doi.org/10.1016/j.humov.2003.09.011>.
- Maxwell, G., Augustine, L., & Granlund, M. (2012). Does thinking and doing the same thing amount to involved participation? Empirical explorations for finding a measure of intensity for a third ICF-CY qualifier. *Developmental Neurorehabilitation*, 15, 274–283.
- Missiuna, C., Rivard, L., & Bartlett, D. (2006). Exploring assessment tools and the target of intervention for children with developmental coordination disorder. *Physical and Occupational Therapy in Pediatrics*, 26(1/2), 71–89.
- Page, P. (2014). Beyond statistical significance: Clinical interpretation of rehabilitation research literature. *International Journal of Sports Physical Therapy*, 9, 726–736.
- Poulsen, A. A., Ziviani, J. M., Cuskelly, M., & Smith, R. (2007). Boys with developmental coordination disorder: Loneliness and team sports participation. *American Journal of Occupational Therapy*, 61, 451–462. <http://dx.doi.org/10.5014/ajot.61.4.451>.
- Poulsen, A. A., Ziviani, J. M., & Cuskelly, M. (2008). Leisure time physical activity energy expenditure in boys with developmental coordination disorder: The role of peer relations in self-concept perceptions. *OTJR: Occupation, Participation and Health*, 28, 30–39. <http://dx.doi.org/10.3928/15394492-20080101-05>.
- Rasmussen, P., & Gillberg, C. (2000). Natural outcome of ADHD with DCD at age 22 years: A controlled longitudinal community based study. *Journal American Academy Child & Adolescent Psychiatry*, 39, 1424–1431.
- Smiths-Engelsman, B., Blank, R., Van Der Kaay, A. C., Mosterd-Van Der Meijis, R., Vlugt-Van Den Brand, E., Polatajko, H. J., et al. (2013). Efficacy of interventions to improve motor performance in children with developmental coordination disorder: A combined systematic review and meta-analysis. *Developmental Medicine & Child Neurology*, 55(3), 229–237.
- Soref, B., Ratzon, N. Z., Rosenberg, L., Leitner, Y., Jarus, T., & Bart, O. (2012). Personal and environmental pathways to participation in young children with and without mild motor disabilities. *Child: Care, Health and Development*, 38(4), 561–571.
- Statistics Canada (2011). *2011 national household survey. Statistics Canada catalogue no. 99-004-XWE*. Ottawa. Version updated May 2013. Retrieved July 10, 2017 from Statistics Canada <http://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/prof/index.cfm?Lang=E>.
- Sylvestre, A., Nadeau, L., Charron, L., Larose, N., & Lepage, C. (2013). Social participation by children with developmental coordination disorder compared to their peers. *Disability & Rehabilitation*, 35, 1814–1820. <http://dx.doi.org/10.3109/09638288.2012.756943>.
- Thornton, A., Licari, M., Reid, S., Armstrong, J., Fallows, R., & Elliott, C. (2016). Cognitive orientation to (daily) occupational performance intervention leads to improvements in impairments, activity and participation in children with Developmental Coordination Disorder. *Disability and Rehabilitation*, 38(10), 979–986.
- Van der Linde, B., Otten, B., Berdien, W., Geuze, R., Schoemaker, M., van Netten, J., et al. (2015). Activities of daily living in children with developmental coordination disorder: Performance, learning, and participation. *Physical Therapy*, 95, 1496–1506. <http://dx.doi.org/10.2522/ptj.20140211>.
- Visser, J. (2003). Developmental coordination disorder: A review of research on subtypes and comorbidities. *Human Movement Science*, 22, 479–493. <http://dx.doi.org/10.1016/j.humov.2003.09.005>.
- Wilson, B. N., Kaplan, B. J., Crawford, S. G., & Roberts, G. (2007). *Developmental coordination questionnaire, 2007 (DCDQ'07)*. Available at: <http://www.dcdq.ca>.
- World Health Organization (WHO) (2007). *International classification of functioning, disability and health: Children and youth version (ICF-CY)*. Geneva, Switzerland: World Health Organization.
- Zwicker, J. G., Harris, S. R., & Klassen, A. F. (2013). Quality of life domains affected in children with developmental coordination disorder: A systematic review. *Child: Care, Health and Development*, 39, 562–580. <http://dx.doi.org/10.1111/j.1365-2214.2012.01379.x>.
- Zwicker, J. G., Missiuna, C., Harris, S. R., & Boyd, L. A. (2012). Developmental coordination disorder: A review and update. *European Journal of Paediatric Neurology*, 16, 573. <http://dx.doi.org/10.1016/j.ejpn.2012.05.005>.
- Zwicker, J. G., Rehal, H., Sodhi, S., Karkling, M., Paul, A., Hilliard, M., et al. (2015). Effectiveness of a summer camp intervention for children with developmental coordination disorder. *Physical & Occupational Therapy in Pediatrics*, 35(2), 163–177. <http://dx.doi.org/10.3109/01942638.2014.957431>.