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## Daily functioning in children with developmental coordination disorder

van der Linde, Berdien

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CHAPTER 5  
ADL PERFORMANCE, LEARNING, AND  
PARTICIPATION IN CHILDREN WITH DCD

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Activities of daily living in children with developmental coordination disorder: performance, learning, and participation

Berdien W. van der Linde, Jaap J. van Netten, Bert Otten, Klaas Postema, Reint H. Geuze, Marina M. Schoemaker

**INTRODUCTION**

Activities of daily living (ADL) are essential for children's daily functioning.<sup>1</sup> Children with developmental coordination disorder (DCD) face difficulties in a broad range of motor-based ADL, e.g. mobility, personal hygiene, feeding, and dressing; handwriting and doing craftwork; ball skills and riding a bike.<sup>2-5</sup> For these children, compared to typically developing peers, poor performance of ADL, delays in learning of ADL, and less frequent participation in ADL are widely suggested in the literature and form part of the diagnostic criteria for DCD.<sup>2-9</sup> However, evidence is scarce: It was concluded in a recent systematic review that little is known about the specific ADL difficulties in children with DCD.<sup>10</sup>

As was emphasized in that systematic review, every effort should be made to report the impact of the disorder on children's daily functioning, and improved understanding of the disorder is needed.<sup>10</sup> This requires standardized assessment of ADL for children with DCD.<sup>10-13</sup> The DCDDaily-Q was recently introduced, which enables investigation of specific ADL difficulties in children with DCD, i.e. how well children perform ADL, whether they have taken longer to learn ADL compared to peers, and how often they perform ADL.<sup>14</sup> This parental questionnaire assesses a broad range of 23 essential ADL known to be difficult for children with DCD,<sup>14</sup> covering the domains of ADL that are relevant for children: "self-care and self-maintenance," "productivity and school" and "leisure and play."<sup>2, 4, 15-19</sup> This comprehensive range of ADL is essential, as full insight into children's difficulties is needed to support diagnosis, assessment, and intervention.<sup>3, 4, 6, 10, 11, 20, 21</sup>

In the current study, differences between a clinical sample of children diagnosed with DCD and their typically developing peers were investigated for the aspects of performance, learning, and participation. The DCDDaily-Q is thus used to specify the difficulties that children with DCD are faced with in daily functioning, in order to investigate the impact of the disorder on the children's daily lives. In addition, the DCDDaily-Q is the first instrument to assess ADL performance, learning, and participation in parallel. This enables investigation of the predictive values of these aspects. We hypothesized that delays in learning of specific ADL precede poor performance in these ADL, which in turn may lead to less frequent participation because children avoid these ADL to prevent failure.<sup>22-25</sup> Further, less frequent participation in specific ADL may cause performance to fall further behind as children do not practice these ADL as often as peers.<sup>22, 23, 25</sup> Shedding light on children's difficulties in ADL performance, learning, and participation, and the relations between these aspects, the DCDDaily-Q may support diagnosis and intervention for individual children with DCD, and facilitate improved understanding of the disorder.

## METHODS

The development of the DCDDaily-Q was extensively described in an earlier study.<sup>14</sup> In short, based on research of the literature and expert involvement, a comprehensive range of 38 ADL was included in the research version of the DCDDaily-Q, to cover the relevant ADL domains of “self-care and self-maintenance,” “productivity and school” and “leisure and play.” A factor analysis indicated that the 23 items remaining in the final version of the DCDDaily-Q reflect the domains of “self-care and self-maintenance,” “fine motor activities,” and “gross motor play activities,” in correspondence with the relevant ADL domains reported in the literature.<sup>14</sup>

For the aspect of performance of ADL, the DCDDaily-Q was found to be a valid and reliable parental questionnaire to address a comprehensive range of ADL in 5 to 8-year-old children with and without DCD.<sup>14</sup> Compared to typically developing peers, children with DCD demonstrated poor performance of all ADL included. In the current study, data on ADL performance are put into new perspective, as additional data are presented on children’s delays in learning of ADL and frequency of participation in ADL, to fully inform professionals about children’s daily functioning.

**Table 1.** Items included in the DCDDaily-Q.

Self-care and self-maintenance	Fine motor activities	Gross motor play activities
1. Buttering a sandwich	11. Writing	18. Playing hopscotch
2. Cutting a sandwich	12. Gluing paper using a glue stick	19. Jumping a rope
3. Pouring juice	13. Folding paper sheets/slips	20. Throwing a tennis ball
4. Opening a wrapper/package	14. Colouring a picture	21. Catching a ball
5. Eating soup with a spoon	15. Cutting paper using scissors	22. Kicking a football
6. Washing hands	16. Lego® building	23. Playing marbles
7. Drying oneself after a shower or bath	17. Moving pawns (on a board)	
8. Brushing teeth		
9. Handling a key		
10. Putting on socks		

To evaluate any relevant difficulties in motor-based daily functioning, parents rate how well children perform each of the ADL included, whether they are taking or have taken longer to learn these ADL compared to peers, and how often they perform these ADL. An overview of the 23 items included in the DCDDaily-Q is provided in Table 1 and one complete item is illustrated in Appendix A. Table 2 provides an explanation of DCDDaily-Q item and total scores for the aspects of performance, learning, and participation.

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**Table 2.** DCDDaily-Q scorings for performance, learning, and participation.

Performance of ADL	Learning of ADL	Participation in ADL
1 = well	0 = is not taking or has not taken longer to learn the activity than peers	1 = regularly
2 = sometimes well and at other times less well	1 = is taking or has taken longer to learn the activity than peers	2 = sometimes
3 = not very well (or badly) most of the time		3 = seldom
		4 = not yet / never

Notes: <sup>a</sup> *Total performance scores* may range from 23 (performs all items well) to 69 (performs all items not very well); *total learning scores* may range from 0 (is not taking or has not taken longer than peers to learn any activity) to 23 (is taking or has taken longer than peers to learn all activities); *total participation scores* may range from 23 (regularly performs all items) to 92 (never performed one of the items);

<sup>b</sup> *Percentage scores* range from 0% (good performance, no delays in learning, and frequent participation) to 100% (poor performance and delays learning of all ADL, and no participation in any of the ADL), calculated as: performance percentage score =  $((\text{total performance score} - 23) / (69 - 23)) * 100$ ; learning percentage score =  $(\text{total learning score} / 23) * 100$ ; participation percentage score =  $((\text{total participation score} - 23) / (92 - 23)) * 100$

In order to compare individual children's scores on the three subscales, DCDDaily-Q total scores were converted to percentage scores, ranging from 0% (good performance in all ADL, no delays in learning any of the ADL, and frequent participation in all ADL) to 100% (poor performance and delays in learning of all ADL, and no participation in any of the ADL).

### Participants

Twenty five children with DCD were included (age (male: female ratio) 5y (4:0), 6y (5:0), 7y (7:2), 8y (5:2)). All of them were referred to a rehabilitation center or physical therapy center in the Netherlands. They were diagnosed by a medical doctor according to the diagnostic criteria for DCD operationalized in the clinical practice guideline for DCD.<sup>9, 11</sup> A control group was composed from a representative reference group, to match for age and gender with the DCD group.<sup>14</sup> Children were selected for this reference group from mainstream primary schools throughout the Netherlands. Schools were selected from various geographic locations, accounting for possible differences between larger cities and smaller villages. From the participating schools, all children aged 5 to 8 years were included (no exclusion criteria applied). From this reference group, children were preliminary selected for the control group when having no known clinical condition such as uncorrected visual problems, and when they were not at risk for DCD (a score equal to or lower than the 16<sup>th</sup> percentile on the Movement Assessment Battery for Children-2 Test (MABC2)).<sup>26</sup> After this pre-selection, 25 children were randomly selected for the control group, matched for age (within one year) and gender with the DCD group.

## Procedure

The 38-item research version of the DCDDaily-Q was sent to parents, who returned it to the researchers after completion. In the current study, data are shown for the 23 items included in the final version of the DCDDaily-Q.<sup>14</sup> The study was approved by the Medical Ethics Committee of the University Medical Center Groningen, the Netherlands.

## Statistical analyses

Analyses were performed using SPSS (IBM SPSS, version 20.0, Chicago, IL, USA). As the distribution of the data was not normal, non-parametric tests were used. Alpha was set at .05.

Missing values were replaced with the mean item score of the child's group (reference or DCD). Per questionnaire, a maximum of four questions remained unanswered; in total, less than 1% of all answers were missing. When participation was rated 4 (= not yet / never performed), parents could not rate performance and learning for that particular item (4% in the DCD group; 2% in the control group). Again, for performance and learning, mean scores of the child's group were used for that item to replace the missing value.

For investigation of the differences between children with DCD and their typically developing peers, mean item scores, mean domain scores, and mean total scores were analyzed for the three subscales of the DCDDaily-Q (performance, learning, and participation). Differences between mean scores in the DCD group and the control group were investigated using Mann-Whitney *U* tests.

Backward stepwise multiple regression analyses were performed to explore the predictive values of performance, learning, and participation. It was hypothesized that (a) learning of ADL would predict performance of ADL; that (b) performance of ADL would predict participation in ADL; and that (c) participation in ADL, in turn, would predict performance of ADL. To analyze hypotheses a and c, *learning* and *participation* were used as predictor variables in Model 1, with *performance* as dependent variable. As a removal criterion for Model 2, the probability of  $F \geq .100$  was used. To analyze hypothesis b, the analyses were repeated with *participation* as dependent variable and *performance* and *learning* as predictors. Finally, interaction effects were investigated by calculating standardized values and including the effects of *performance* \* *learning* on *participation* and *learning* \* *participation* on *performance*. For all models, data are provided for DCDDaily-Q total scores, for the DCD group and the control group separately.

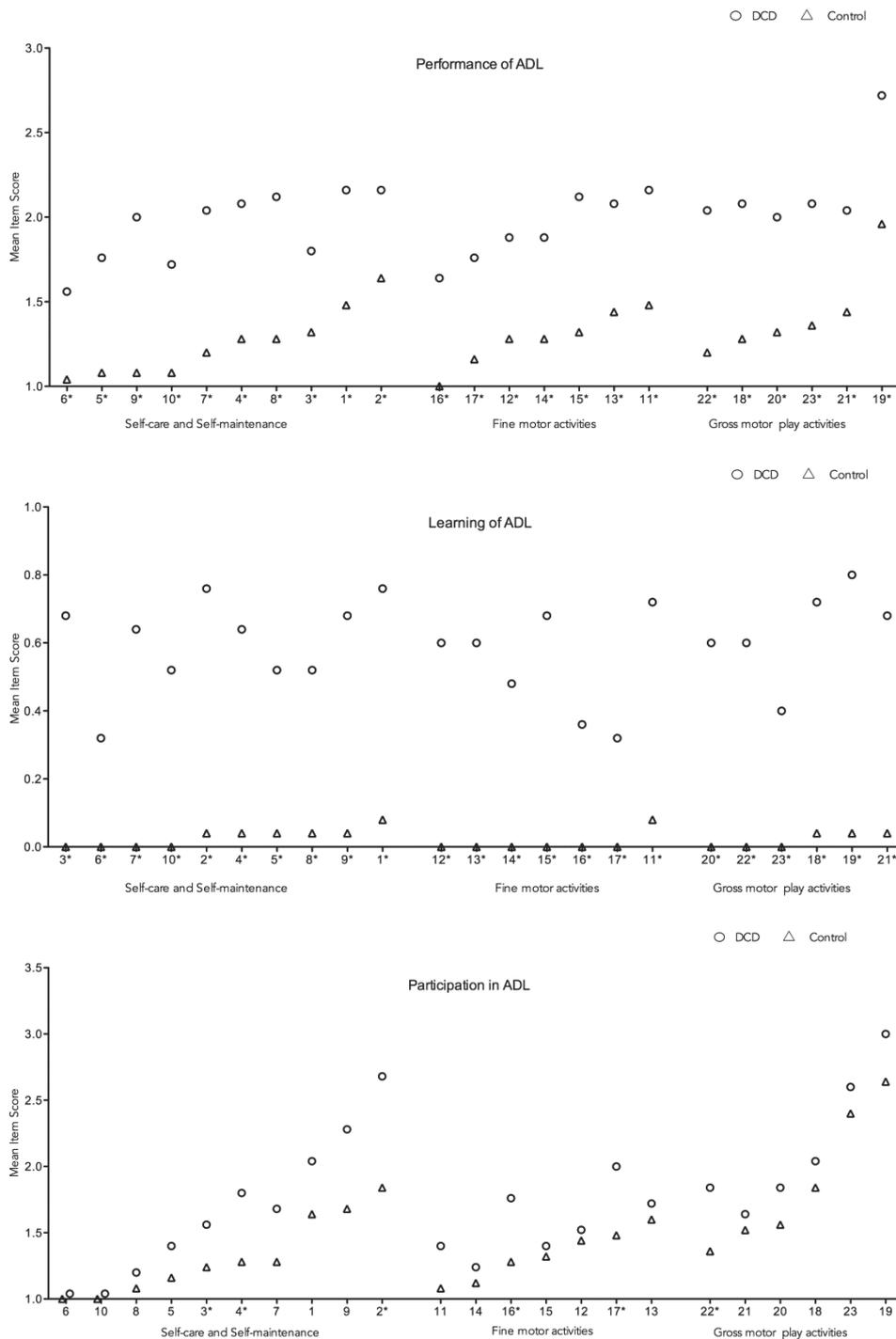
**RESULTS**

According to their parents, children with DCD showed poor performance of ADL compared to their matched controls: Significant differences were found between groups for mean DCDDaily-Q total performance scores ( $p < .001$ ), mean domain scores (all:  $p < .001$ ), and each of the 23 mean item scores (all:  $p \leq .005$ , see Figure 1).

Parental rating demonstrated delays in learning of ADL in children with DCD compared to peers: Significant differences were found between groups for mean DCDDaily-Q total learning scores ( $p < .001$ ), mean domain scores (all:  $p < .001$ ), and each of the 23 mean item scores (all:  $p \leq .002$ , see Figure 1). In more detail, five children with DCD (20%) showed a delay in learning of all ADL included (total learning score = 23; percentage score = 100) and the majority of children in the DCD group (64%) showed a delay in learning more than half of the ADL included (total learning score  $\geq 12$ ; percentage score  $\geq 50$ ), whereas the maximum total learning score was 4 (percentage score  $\leq 17$ ) in the control group (see Figure 2). The majority of children in the control group (76%) showed no delay in learning in any of the ADL, compared to one child in the DCD group (4%; total learning score = 0; percentage score = 0; see Figure 2).

Children with DCD participate in ADL less frequently than their matched controls: Significant differences were found between groups for mean total participation scores ( $p = .001$ ) as well as for the mean domain scores (self-care and self-maintenance ( $p = .001$ ), fine motor activities ( $p = .022$ ), and gross motor play activities ( $p = .046$ )). Considering the specific ADL, parents acknowledged children with DCD to participate less frequently in 6 out of 23 activities: cutting a sandwich, pouring juice, opening a wrapper / package, Lego® building, moving pawns, and kicking a football (see Figure 1).

# ADL PERFORMANCE, LEARNING, AND PARTICIPATION



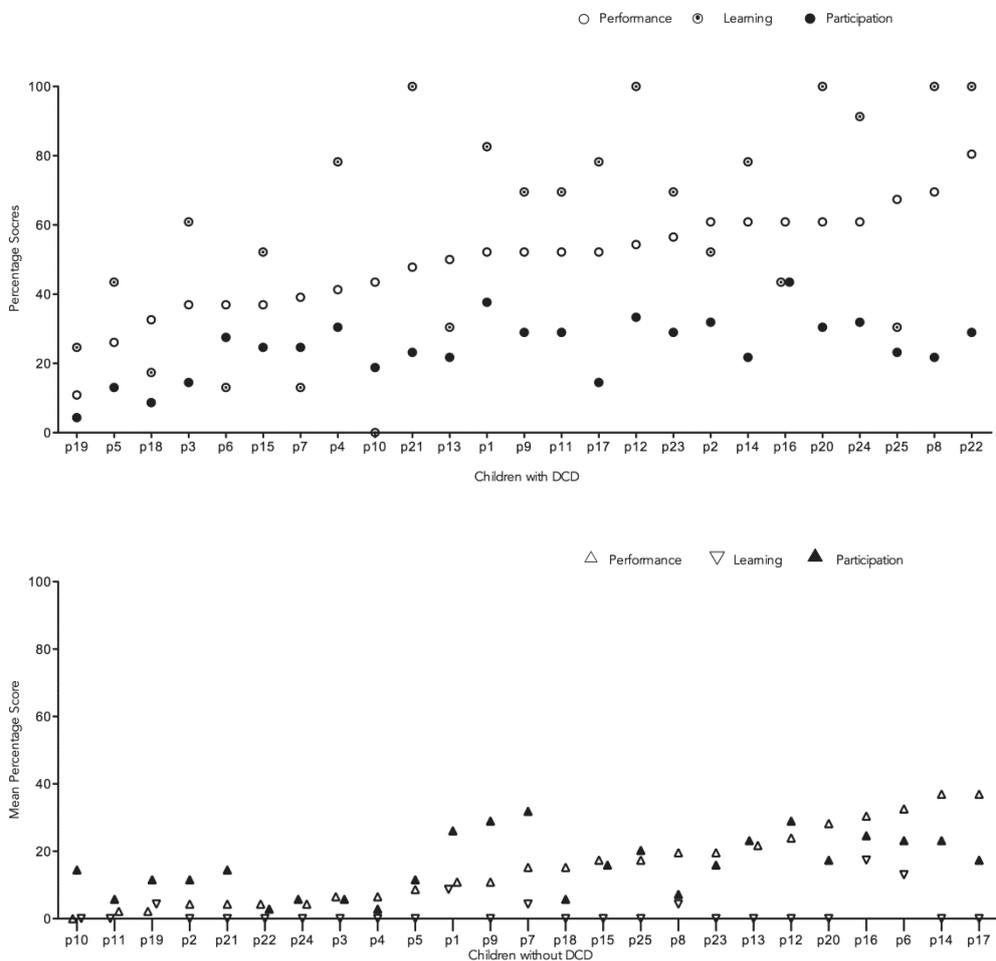
**Figure 1.** ADL performance, learning, and participation in children with and without DCD.

Notes: The items are organized per domain and sequenced from good to poor, for the mean DCDDaily-Q scores in the control group (performance scores range from 1 (good) to 3 (poor); learning scores range from 0 (did not take long to learn compared to peers) or 1 (took long to learn the ADL compared to peers); and participation scores range from 1 (often performed) to 4 (never performed)). DCD = developmental coordination disorder; ADL = activities of daily living. Items: *Self-care and self-maintenance*: 1 = Buttering a sandwich, 2 = Cutting a sandwich, 3 = Pouring juice, 4 = Opening a wrapper/package, 5 = Eating soup with a spoon, 6 = Washing hands, 7 = Drying him/herself after a shower or bath, 8 = Brushing teeth, 9 = Handling a key, 10 = Putting on socks; *Fine motor activities*: 11 = Writing, 12 = Gluing paper using a glue stick, 13 = Folding paper sheets/slips, 14 = Colouring a picture, 15 = Cutting paper using scissors, 16 = Lego® building, 17 = Moving pawns (on a board); *Gross motor play activities*: 18 = Playing hopscotch, 19 = Jumping a rope, 20 = Throwing a tennis ball, 21 = Catching a ball, 22 = Kicking a football, 23 = Playing marbles. \* = significant with alpha < .05.

**Performance, learning, and participation**

Percentage scores on performance, learning, and participation were below the 40<sup>th</sup> percentile for all children in the control group, indicating good performance in most ADL, no delays in learning in most of the ADL, and frequent participation in most of the ADL; for the majority of children in the DCD group, percentile scores were above the 40<sup>th</sup> percentile for performance and learning of ADL (see Figures 1 and 2).

For children with DCD, percentage scores on performance, learning, and participation ranged from 0% to 100%, reflecting heterogeneous patterns in their scores on the three subscales (see Figure 2). Heterogeneity in performance and learning were demonstrated in Figures 1 and 2: Difficulties are seen in each of the ADL included and of the individual children with DCD, some showed difficulties in only some ADL and others in all ADL.



**Figure 2.** Percentage scores for ADL performance, learning, and participation, for all children in the DCD and the control group.

Notes: Children's scores are sequenced according to their performance scores, from good to poor. Percentage scores range from 0% (good performance, no delays in learning, and frequent participation) to 100% (poor performance and delays in learning of all ADL, and no participation in any of the ADL). DCD = developmental coordination disorder.

**Relations between performance, learning, and participation**

In the DCD group, regression analyses of the DCDDaily-Q total scores demonstrated (a) delays in learning to predict poor performance, and (b) poor performance to predict less frequent participation, but (c) less frequent participation did not predict poor performance (see Table 3). In the control group, regression analyses of DCDDaily-Q total scores demonstrated (b) performance to predict participation, as well as (c) participation to predict performance (see Table 3).

No interaction effects were found (DCD group:  $p = .713$  for learning \* participation on performance,  $p = .899$  for performance \* learning on participation; Control group:  $p = .468$  for learning \* participation on performance,  $p = .170$  for performance \* learning on participation).

**Table 3.A** Backward regression analyses for mean DCDDaily-Q total performance scores.

	DCD group				Control group			
	<i>B</i> (SE)	$\beta$ (95% CI)	<i>p</i> -value	$R^2$	<i>B</i> (SE)	$\beta$ (95% CI)	<i>p</i> -value	$R^2$
Total score								
Model 1				.42				.30
<i>Learning</i>	0.48 (0.16)	.53 (0.16 - 0.81)	.005*		0.83 (0.96)	.16 (-1.16 - 2.81)	.396	
<i>Participation</i>	0.32 (0.22)	.25 (-0.13 - 0.77)	.158		0.40 (0.17)	.47 (0.06 - 0.75)	.024*	
Model 2				.37				.28
<i>Learning</i>	0.55 (0.15)	.61 (0.24 - 0.87)	.001*					
<i>Participation</i>					0.45 (0.15)	.53 (0.14 - 0.77)	.007*	

**Table 3.B.** Backward regression analyses for mean DCDDaily-Q total participation scores.

	DCD group				Control group			
	<i>B</i> (SE)	$\beta$ (95% CI)	<i>p</i> -value	$R^2$	<i>B</i> (SE)	$\beta$ (95% CI)	<i>p</i> -value	$R^2$
Total score								
Model 1				.18				.32
<i>Performance</i>	0.28 (0.19)	.36 (-0.12 - 0.68)	.158		0.53 (0.22)	.45 (0.08 - 0.98)	.24*	
<i>Learning</i>	0.07 (0.18)	.10 (-0.29 - 0.43)	.698		1.23 (1.08)	.21 (-1.01 - 3.48)	.267	
Model 2				.17				.28
<i>Performance</i>	0.33 (0.15)	.41 (0.02 - 0.64)	.040*		0.61 (0.21)	.53 (0.18 - 1.03)	.007*	

Notes: <sup>a</sup>\* = Significant with alpha < .05; <sup>b</sup> Analyses were performed with DCDDaily-Q total scores of children in the DCD group ( $n = 25$ ) and their matched controls ( $n = 25$ ); <sup>c</sup> DCD = developmental coordination disorder

**DISCUSSION**

The first aim of this study was to investigate difficulties in daily functioning for children with DCD. The DCDDaily-Q was used to assess children's performance, learning, and participation in a broad range of essential ADL, in order to elucidate the consequences of DCD for the individual child. This study is the first to quantify what has been suggested in the literature: Children with DCD show poor performance of ADL, delays in learning of ADL, and less frequent participation in ADL compared to their typically developing peers.<sup>2-6, 9, 24, 27</sup>

Interestingly, for the majority of the specific ADL included in the DCDDaily-Q (17 out of 23), parents rated children with DCD to participate as often as peers. Children with DCD were found to participate less frequently in those ADL that can be avoided, e.g. kicking a football, Lego® building, and moving pawns on a board, or that can be "taken over" by parents, such as cutting a sandwich, pouring juice, and opening wrappers/packages. It was demonstrated earlier that children with DCD avoid certain ADL when their poor performance disturbs other children, e.g. in playing games.<sup>6-8, 25</sup> Further, as the poor performance in children with DCD puts pressure on the entire family, parents may "take over" activities such as preparing food, in order to prevent the mess of spilled juice or dangerous situations involving the knife; or purchase supportive materials such as Velcro shoes to prevent endless attempts of getting dressed during the morning rush to get to school.<sup>6-8</sup> For all other ADL included in the DCDDaily-Q, parents rated children with DCD to participate as often as peers. Apparently, avoidance or adaptations are uncommon for these ADL, e.g. children have to wash their own hands and participate in school activities such as writing and tinkering, and children participate as often as peers in play activities such as catching balls and playing hopscotch. Given their poor performance in these ADL, this must be a frustrating experience.

A second important result of this study considers the heterogeneity of DCD. It is well-known that children with DCD show heterogeneous performance.<sup>5</sup> Some children face difficulties in handwriting only, others lack specific skills such as ball skills, and others may experience severe "clumsiness" in multiple motor domains.<sup>2, 9</sup> The current study is the first to assess children's difficulties in a broad range of ADL with a valid and reliable instrument. The heterogeneity in ADL performance and learning in children with DCD as revealed with the DCDDaily-Q stresses the range of differences between individual children with DCD and, with that, the need for tailored intervention. Moreover, the DCDDaily-Q may support the investigation of possible subtypes of DCD.<sup>28</sup> When future studies would demonstrate comparable patterns of difficulties in ADL performance, learning, or participation in larger groups of children with DCD, different mechanisms laying behind the motor problems in these subgroups may be explored.

Finally, the relation between the aspects of performance, learning, and participation was explored: (a) Delays in learning of ADL were hypothesized to predict poor performance of ADL. In children with DCD, delays in learning were indeed found a predictor for poor performance. This is an excellent starting point for assessment, as early recognition of delays in learning may support intervention to prevent performance difficulties. This is important, as children's further motor development is challenged when their performance stays behind because of delays in learning of ADL.<sup>3, 22</sup> In the control group, learning was not found to predict performance, likely due to the small variation in total learning scores; (b) Performance of ADL was hypothesized to predict participation in ADL, as poor performance in specific ADL might lead to avoidance or adaptations as described above.<sup>3, 22, 23, 25</sup> This hypothesis was confirmed in both children with DCD and their typically developing peers. This suggests that interventions aimed to improve performance of ADL also reinforce children's participation in ADL. It is worthwhile to evaluate this in future research as more frequent participation may support prevention or limitation of secondary consequences such as low self-esteem and social exclusion<sup>3, 22, 25</sup>; (c) Participation was hypothesized to predict performance, because performance may fall behind when children do not practice certain ADL as often as peers.<sup>22, 23, 25</sup> In the control group, more frequent participation was associated with better performance of ADL. In the DCD group, however, this was not the case. As it appears, the relatively poor performance of children with DCD was not due to less frequent participation in these ADL compared to peers. Indeed, for 17 out of the 23 ADL included, parents rated their children to participate as often as peers. For these children, a lack of practice does not explain their poor ADL performance. Thus, in order to improve their ADL performance, more is needed than practice alone, i.e. task-specific interventions, which were found effective to improve children's performance.<sup>5, 29</sup>

### **Limitations**

A first limitation of this study is the use of a questionnaire, which is a subjective form of assessment. However, parental questionnaires do provide a valuable source of information<sup>30</sup> as they provide a long-term perspective instead of results of specific moments of testing. Second, although the clinical sample used in the study is promising, it must be noted that this study comprises data on performance, learning, and participation of only 25 children with DCD. Further, only 4 girls were included, but this represents the male: female ratio in the DCD population.<sup>31</sup> In future studies it is recommended to assess a larger sample, in order to investigate possible differences between groups of age and gender.

## CHAPTER 5

### CONCLUSIONS

Children with DCD demonstrated poor performance of ADL, delays in learning of ADL, and less frequent participation in ADL, compared to typically developing peers. These difficulties in daily functioning clearly indicate the impact of the disorder on these children's daily lives. Further, heterogeneous patterns were found in children with DCD for performance and learning of ADL, which stresses the need for tailored intervention. Finally, in children with DCD, learning was found to predict performance of ADL, and performance was found to predict participation in ADL.

# ADL PERFORMANCE, LEARNING, AND PARTICIPATION

## APPENDIX

Appendix A. Example and general explanation for the questions in the DCDDaily-Q.

<b>1.</b>	<b>a. Activity</b> <i>Buttering a sandwich</i>	<b>c. Correct performance</b> <i>The right amount of butter is neatly and evenly spread, at a normal pace, without making a mess and without dangerous situations involving the knife</i>	
	<b>b. Participation</b> My child does this...	<b>d. Quality</b> My child can do this...	<b>e. Acquisition</b> My child ...
	<input type="checkbox"/> 1. regularly	<input type="checkbox"/> 1. well	<input type="checkbox"/> is taking or has taken longer to learn this skill than his/her age peers
	<input type="checkbox"/> 2. sometimes	<input type="checkbox"/> 2. sometimes well and at other times less well	
	<input type="checkbox"/> 3. seldom	<input type="checkbox"/> 3. not very well (or badly) most of the time	
	<input type="checkbox"/> 4. not yet / never		

**Step 1:** In the first text box **a. Activity**, the motor action is described, *buttering a sandwich* in our example.

**Step 2:** In the column below, **b. Participation**, we ask you to indicate how often your child performs this activity. You tick the box

1. **regularly**, when your child butters or tries to butter a sandwich often, for instance every day;
2. **sometimes**, when your child butters or tries to butter a sandwich every now and then;
3. **seldom**, when your child only rarely butters a sandwich. He/She may, for instance, have tried but was unable to or does not feel like doing it and hardly ever tries;
4. **not yet / never**, when your child has never buttered a sandwich, possibly because you think it is too difficult or too dangerous for your child. > You can skip columns d. and e.

**Step 3:** In text box **c. Correct performance**, we describe what we consider to be the right way to perform the activity. In our example: *The right amount of butter is neatly and evenly spread, at a normal pace, without causing a mess and without dangerous maneuvers with the knife.*

**We urge you** to read these 'correct performance' definitions carefully and to use this definition to judge the way your child performs the activity.

**Step 4:** In column **d. Quality**, you are asked to choose the option that best describes the way your child performs the activity described. You tick

1. **well** when your child generally performs the activity *as described* in c.;
2. **sometimes well and at other times less well** when your child does not always perform the activity as described in c. Your child occasionally gets butter on his/her fingers or on the table, for instance;
3. **not very well (or badly) most of the time** when your child as a rule does not perform the activity as described in c. Your child tends to be messy or has more difficulty buttering his/her sandwich or takes longer than other children of his/her age.

**Step 5:** You tick the box in column **e. Acquisition** when you think it took or is taking your child longer than other children of about the same age to learn to master the activity as described in c.

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