Daily functioning in children with developmental coordination disorder

van der Linde, Berdien

CHAPTER 3
THE DCDDAILY

See also *Clinical Rehabilitation 2013: 27(9), 834-844, DOI: 10.1177/0269215513481227*
Development and psychometric properties of the DCDDaily: A new test for clinical assessment of capacity in ADL in children with developmental coordination disorder

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

INTRODUCTION

Children with developmental coordination disorder (DCD) experience motor difficulties in a broad range of activities of daily living (ADL), such as mobility, personal hygiene, feeding, and dressing; handwriting and crafting; ball skills, and riding a bike.[1-3] Moreover, owing to their limited capacity in ADL, children's participation may be restricted and psycho-social consequences may arise, such as low self-esteem and social exclusion.[3-6] The great impact of DCD on children's daily lives necessitates proper diagnosis and intervention, in order to limit the consequences of the disorder.[7-9]

Difficulties in ADL form one of the inclusive diagnostic criteria for DCD (Criterion B), according to both the Diagnostic and Statistical Manual of Mental Disorders (DSM) and the recently developed clinical practice guideline for DCD.[1, 2] Assessment of capacity in ADL is thus required to obtain a comprehensive diagnosis of DCD.[1, 2, 9, 10] Capacity is defined as what a child is capable of in a standardized environment.[11, 12] This necessitates a standardized and objective clinical instrument to assess ADL. Assessment of capacity in ADL would also be a starting point for therapy, as insight into the functional problems of a child may help clinicians to specify treatment goals.[2, 8, 13]

Despite the importance of ADL, and the need for assessment thereof, current instruments do not provide comprehensive assessment of capacity in ADL in children with DCD.[2, 9, 14] Standardized and objective instruments that are most commonly used to assess children with DCD are the Movement Assessment Battery for Children-2 (MABC2) Test and the Bruyninks-Oseretsky Test of Motor Proficiency-2 (BOT2).[2, 6, 15-17] With these instruments, however, emphasis lies on the measurement of movement skills (Criterion A of the diagnostic criteria for DCD according to the DSM), rather than assessment of ADL (Criterion B).[1, 2, 8, 18] Other instruments, which may be used for assessment of capacity in ADL in children, are for example the Do-Eat, and the school version of the Assessment of Motor and Process Skills (schoolAMPS).[19-21] These instruments however, do not provide comprehensive assessment of ADL, despite the importance to cover a broad range of ADL in a heterogeneous disorder such as DCD.[4, 9, 22, 23]

For assessment of Criterion B, questionnaires are currently used, such as the Developmental Coordination Disorder Questionnaire (DCDQ) and the MABC2 Checklist.[1, 2, 16, 24] However, according to the clinical practice guideline for DCD, a reliable method is urgently needed for clinical assessment of Criterion B.[2] Questionnaires are designed to assess performance, which reflects what a child's does in daily life.[11, 25] What a child does, i.e. ADL performance, may differ from what a child is capable of, i.e. capacity in ADL.[11, 25] Moreover, as questionnaires are mainly subjective, they can only assist in screening for DCD and do not suffice for identification or scaling of the disorder.[2, 25, 26] Questionnaires are of use to obtain insight into participation and into ADL that cannot be

addressed with objective instruments due to ethical or environmental constraints, e.g. bathing and riding a bike. For comprehensive assessment of ADL in children with DCD, a combination is thus needed of standardized and objective assessment of the child's capacity in ADL, and subjective assessment of the child's performance.[2, 25, 27] Despite the need for an instrument for standardized and objective assessment of capacity in ADL, this is currently lacking for children with DCD.

To fill this gap, a new test was designed to provide standardized and objective clinical assessment of capacity in ADL in five to eight-year-old children with DCD: the DCDDaily. Aim of the current study was the development of the DCDDaily and investigation of its usability, reliability, and validity.

THE DCDDAILY

The design of the *research version* of the DCDDaily comprised five phases. Subsequently, for this *research version*, usability, reliability, and validity were analyzed. Adaptations were made based on the results of these analyses, entailing the *final version* of the DCDDaily.

Design

During the first phase, a theoretical model was described for the DCDDaily. Relating to the model of the International Classification of Functioning, Disability and Health (ICF), which is the universal framework for health-related conditions, ADL are defined as "motor-based activities with a functional or meaningful goal that are performed on a daily basis".[12] In order to cover ADL in a comprehensive way, the three domains of ADL were used as a basis for inclusion of items in the DCDDaily: "self-care and self-maintenance," "productivity and schoolwork," and "leisure and play".[9, 28]

Secondly, five specifications were set for the DCDDaily, based on the literature: (a) Assessment of ADL should be standardized and objective, to ensure reliable and valid test results [2, 8, 14]; (b) Assessment of ADL should encompass all three domains of ADL, as DCD is a heterogeneous disorder that is represented by a wide range of variation in everyday performance [4, 5, 9, 22, 23]; (c) ADL should be assessed that are part of daily functioning in five to eight-year-old children. This age range was considered appropriate as DCD is often recognized around school-age [23]; (d) Assessment of ADL should be ecologically valid, in order to optimally reflect the child's functioning.[19, 29-31] An ecologically valid test comprises of items that represent those ADL that are performed during actual daily life. Further, these ADL should be assessed in a natural setting to render generalizable test

results; (e) The instrument should be easy to use, assessable in any clinical setting, and assessment time should be limited to 30 minutes.

Thirdly, the relevant literature was explored and experts were interviewed, in order to select items for inclusion in the DCDDaily. An overview was obtained of ADL that are daily routine for five to eight-year-old children, and that children with DCD experience problems with. The literature review was conducted, with the databases of MEDLINE (1989-2007), EMBASE (1989-2007), EBSCO (1989-2007), and Web of Science ISI (1989-2007) searched by two reviewers, for papers describing ADL in children with DCD, using the following keywords: "developmental coordination disorder" and "activities of daily living." In order to complete this overview, semi-structured expert-interviews were held with physical therapists (n = 2), occupational therapists (n = 2), and scientists (1 rehabilitation researcher and 1 psychologist), who regularly work with children with DCD.

The fourth phase comprised an expert meeting to discuss the list of relevant ADL, and to reach consensus on the items to be included in the DCDDaily. The experts were occupational therapists (n = 2), physical therapists (n = 2), a pediatrician (n = 1), a clinical neuropsychologist (n = 1), and researchers in psychology, pediatric rehabilitation, human movement sciences (n = 3), all working in the field of DCD for more than ten years. Two of the researchers involved are also authors of the current study. Consensus was reached on the items to be included in the DCDDaily, feasibility issues were discussed, an ecologically relevant sequence of the items was agreed on, instructions to be given during assessment were formulated, and a simple and transparent scoring system was designed (see Appendix A). The expert meeting resulted in the *pilot version* of the DCDDaily, which comprised seventeen items, embedded in a story of simulating "a regular day."

In the fifth phase, a pilot study was performed with 9 children with DCD and 26 children that were typically developing. For practical reasons, children aged 7 and 8 years were included only. Although the results regarding feasibility and psychometric properties of the DCDDaily were promising, adaptations were made for all items in order to optimize assessment. Experts were again involved in this process, who were also involved in the expert meeting, e.g. an occupational therapist, a physical therapist, and two researchers in psychology and human movement sciences. Furthermore, four advanced students in human movement sciences were involved, who had assessed children with the *pilot version* of the DCDDaily. This resulted in the *research version* of the DCDDaily.

Validation

Following these five phases, reliability and validity analyses were performed as described in the current study. The results showed three out of 21 items of the *research version* not to be differentiating between children with and without DCD. These items were therefore deleted, resulting in the *final version* of the DCDDaily, holding 18 items.

The *research version* of the DCDDaily comprised a sequence of 21 items that simulate "a regular day": starting with breakfast, going to school, having a break, getting dressed, and ending with free time. Table 1 shows the sequence of assessment of the items and the related domains of ADL.

For all items, both *success* and *time* were scored. *Success* scores were defined per item, i.e. what is a (1) successful, (2) medium, or (3) poor performance; *time* is scored in seconds and subsequently standardized into (1) good, (2) medium, or (3) poor, based on norm scores (for an extensive description of the *success* and *time* scores, calculation of the norm scores, and an example of item description, see Appendix A). *DCDDaily item scores* are calculated as the average of *success* and *time* scores per item (resulting in 21 *item scores* of 1 - 1.5 - 2 - 2.5 - 3). The *DCDDaily total score* is calculated as the sum of 21 *DCDDaily item scores*, ranging from 21 (good) to 63 (poor).

Scoring the quality of the movement, i.e. how the item is carried out, was considered less relevant, since (I) a successful performance can be reached in several ways;[27] and (II) inefficiency will be reflected in the time needed to perform the item. For the clinician involved, however, insight into the quality of certain ADL, may provide additional information to guide the planning of intervention.[32]

Table 1. Items included in the research version of the DCDDaily, sequenced to reflect "a regular day."

1. Home	2. School	3. Break	4. Shopping (dressing)	5. Free time
Buttering a piece of gingerbread [a]	Writing [b]	Lego® building [c]	Tying shoelaces [a]	Playing marbles [c*]
Cutting a piece of gingerbread [a]	Gluing paper using a glue stick [b]	Pouring juice [a]	Putting on trousers [a]	Playing hopscotch [c]
Opening and closing a lunchbox [a*]	Folding paper slips [b]	Walking with a filled cup [a]	Putting on a polo [a]	
Opening and closing a backpack [a]	Colouring a picture [b]	Eating with a spoon [a]	Putting on a body-warmer [a]	
Walking with a chair [a*]	Cutting paper with scissors [b]	Opening a package [a]		

Notes: [a] Activities from the domain of "self-care and self-maintenance"; [b] Activities from the domain of "productivity and school"; [c] Activities from the domain of "leisure and play"; [d] Items excluded from the final version of the DCDDaily are marked with an *

METHODS

Five to eight-year-old children, both with and without DCD, were assessed with the *research version* of the DCDDaily to analyze usability, reliability, and validity of the instrument.

Participants

Two groups of children were selected, a DCD group and a normative reference group. All children in the DCD group were diagnosed by a medical doctor in a rehabilitation center or physical therapy center in the Netherlands, according to the criteria for DCD operationalized in the international clinical practice guideline for DCD:[2] (a) a score equal to or lower than the 16th percentile on the MABC2 Test; (b) an indication for problems with ADL (currently operationalized as a score equal to or lower than the 15th percentile on the DCDQ or MABC2 Checklist); and (c) the absence of a general medical condition (e.g., cerebral palsy, hemiplegia, or muscular dystrophy or pervasive developmental disorder) according to the results of a pediatric neurological examination. Further, only children with IQ scores above 70 were included.[1] The reference group comprised a representative sample of the Dutch population of five to eight-year-old children, selected from mainstream primary schools throughout the Netherlands. Schools were selected from various geographic locations, accounting for possible differences between larger cities and smaller villages. As a control group, a third group was composed to enable comparison of children with DCD and typically developing children, needed for validity analyses. The control group comprised children randomly selected from the reference group, matched for age (within one year) and gender with the DCD group. Children who had a known clinical condition such as uncorrected visual problems, or who were at risk for DCD (a score equal to or lower than the 16th percentile on the MABC2 Test), were excluded from selection for the control group.

Procedure

The study was approved by the Medical Ethics Committee of the University Medical Center Groningen in the Netherlands. After informed consent was obtained from their parents, children were assessed with the DCDDaily and the MABC2 Test, in a separate room in their school or rehabilitation center. Assessors were advanced students with a background in human movement science or physical therapy, who were trained in the assessment of the MABC2 Test and the DCDDaily, but who had not been involved in the design of the instruments. The DCDQ and MABC2 Checklist were sent to the parents, who returned these to the researchers after completion.

Statistical analysis

For test-retest reliability analyses, a random group of children from the reference group performed a retest within two weeks of the original assessment, with the same assessor. Retests were not assessed for children with DCD, because this would create too much pressure on these children as their referral to clinical rehabilitation already involved an extensive diagnostic process. For inter-rater reliability, data were used from both the reference group and the DCD group. A random set of children was videotaped during assessment, after additional informed consent. Subsequently, this assessment was rated by two assessors, who separately observed the same video.

Data analyses were performed using SPSS Statistics Data Editor (IBM SPSS, version 20.0, Chicago, IL, United States of America). Because the distribution of data was not normal, non-parametric tests were used. Alpha was set at 0.05.

For reliability, test-retest reliability, inter-rater reliability, and internal consistency of the DCDDaily were analyzed. Test-retest and inter-rater reliability were determined by calculating intra-class correlations for DCDDaily total scores, with data of children from the reference group and both the reference group and DCD group used respectively. Two-way mixed effects models of the absolute agreement type intra-class correlations were used, and output of the 'single measure' interpreted, with intra-class correlations values > 0.75 as excellent reliability; 0.40 – 0.75 as fair-to-good reliability; and < 0.40 as poor reliability.[33] The internal consistency of the DCDDaily was investigated calculating Cronbach's α for the DCDDaily item scores of all children included, with 0.70 stipulated as an acceptable level.[34]

For validity, concurrent validity was determined calculating Spearman's ρ for mean DCDDaily total scores (a higher score means poorer performance) and mean percentile scores on the MABC2 Test (a higher score means better performance), and MABC2 Checklist (a higher score means poorer performance) and DCDQ total scores (a higher score means better performance), using data of all children included. Furthermore, a receiver-operator characteristics curve was composed to analyze the agreement between the indication for DCD based on the DCDDaily score, with this indication based on the current diagnostic criteria, using data of the DCD group and the control group. The receiver-operator characteristics curve was used to determine an appropriate cut-off point for the DCDDaily score to indicate DCD, accounting for optimal sensitivity and specificity, e.g. at or above 0.80.[35] Further, the area under curve statistic was calculated to reflect the probability that a child with DCD (according to the current diagnostic criteria) has a worse score on the DCDDaily than a typically developing child, with a value above 0.80 considered high.[36] Finally, discriminant validity of the DCDDaily was determined by calculating differences between the DCD group and the control group for mean DCDDaily total scores and for mean DCDDaily item scores, using Mann-Whitney U tests.[33]

RESULTS

In total, 459 five to eight-year-old children were included, with 55 children in the DCD group and 404 children in the reference group. Further, the control group was composed of 55 children selected from the reference group. Descriptive statistics of the three groups are shown in Table 2. For analysis of the test-retest reliability, 20 children from the reference group were assessed with a retest; for inter-rater reliability analysis, assessments of 7 children from the DCD group and 7 children from the reference group were video-taped.

Table 2. Descriptive statistics of the reference group, DCD group, and control group, per age group.

	Male: Female ratio	Mean MABC2 (SD; range)	Mean MABC2Q (SD;, range)	Mean DCDQ (SD; range)
Reference group				
n=404; age=7.1 (1.1)	**199:205**	**49 (29; 0.1-99)**	**3 (5; 0-34)**	**45 (22; 0-75)**
Age 5 (n=73)	41:32	42 (27; 0.5-98)	4 (6; 0-20)	41 (21; 11-74)
Age 6 (n=119)	51:68	46 (28; 1-99)	3 (5; 0-25)	42 (21; 0-74)
Age 7 (n=108)	54:54	52 (30; 0.1-99)	3 (5; 0-34)	47 (23; 0-75)
Age 8 (n=104)	53:51	55 (30; 0.1-99)	3 (5; 0-20)	49 (23; 0-75)
DCD group				
n=55; age=7.0 (1.0)	**47:8**	**6 (5; 0.1-16)**	**21 (13; 0-51)**	**34 (16; 6-36)**
Age 5 (n=5)	5:0	6 (3; 1-9)	14 (7; 7-23)	47 (25; 10-36)
Age 6 (n=9)	9:0	7 (6; 0.5-16)	22 (10; 6-36)	38 (13; 22-59)
Age 7 (n=21)	17:4	7 (6; 0.1-16)	24 (14; 0-44)	31 (14; 6-57)
Age 8 (n=20)	16:4	5 (6; 0.1-16)	18 (14; 0-51)	31 (15; 9-51)
Control group				
n=55; age=7.0 (1.0)	**47:8**	**59 (25; 25-98)**	**4 (6; 0-25)**	**46 (24; 14-75)**
Age 5 (n=5)	5:0	42 (25; 25-84)	6 (7; 0-13)	47 (24; 24-71)
Age 6 (n=9)	9:0	51 (25; 25-84)	11 (10; 0-25)	31 (20; 15-70)
Age 7 (n=21)	17:4	60 (23; 25-98)	2 (4; 0-13)	49 (23; 14-75)
Age 8 (n=20)	16:4	66 (26; 25-95)	2 (5; 0-20)	47 (26; 17-75)

Notes: [a] Reference group: representative sample of the Dutch population; DCD group: children diagnosed according to the current diagnostic criteria for developmental coordination disorder; Control group: typically developing children, selected from the reference group, matched for age and gender with the DCD group; [b] MABC2 = Movement Assessment Battery for Children-2 Test percentile score; MABC2Q = Movement Assessment Battery for Children-2 Checklist total score; DCDQ = Developmental Coordination Disorder Questionnaire total score; [c] DCD = developmental coordination disorder; n = Number of children, per group; age = age mean (SD)

Research version

Assessment with the DCDDaily did not exceed 25 minutes for children in the reference group, or 30 minutes for children with DCD. Materials were easy to transport and set up, and assessment was possible in all clinical settings.

For internal consistency of the DCDDaily, Cronbach's α = 0.83. The intra-class correlation for test-retest reliability of the DCDDaily was 0.87, the intra-class correlation for inter-rater reliability was 0.89.

For concurrent validity, significant correlations were found between mean DCDDaily total scores and mean MABC2 Test percentile scores, MABC2 Checklist total

scores, and DCDQ total scores, ρ = -0.494, ρ = 0.239, and ρ = -0.284 respectively (p < 0.001).

For discriminant validity, mean DCDDaily total scores were significantly higher for the DCD group than for the control group, indicating that children with DCD performed worse (mean (SD) DCD group=33 (5.6); control group=26 (4.3), p < 0.001). Further, significant differences were found between the groups for 17 out of 21 DCDDaily item score means (Mann-Whitney U Test range from p < 0.001 to p < 0.005 for these 17 items). The items "opening and closing a lunchbox" (item 3, p = 0.852), "walking with a chair" (item 5, p = 0.721), "walking with a filled cup" (item 13, p = 0.056), and "playing marbles" (item 20, p = 0.136), did not differentiate between groups, see Figure 1.

Item 13, "walking with a filled cup," did differentiate for the group of children of six years and older (p = 0.034). As they did not differentiate between children with and without DCD, the items 3, 5, and 20 were excluded from the *final version* of the DCDDaily (total score ranging from 18 (good) to 54 (poor)). Further analyses were performed with this *final version* of the DCDDaily.

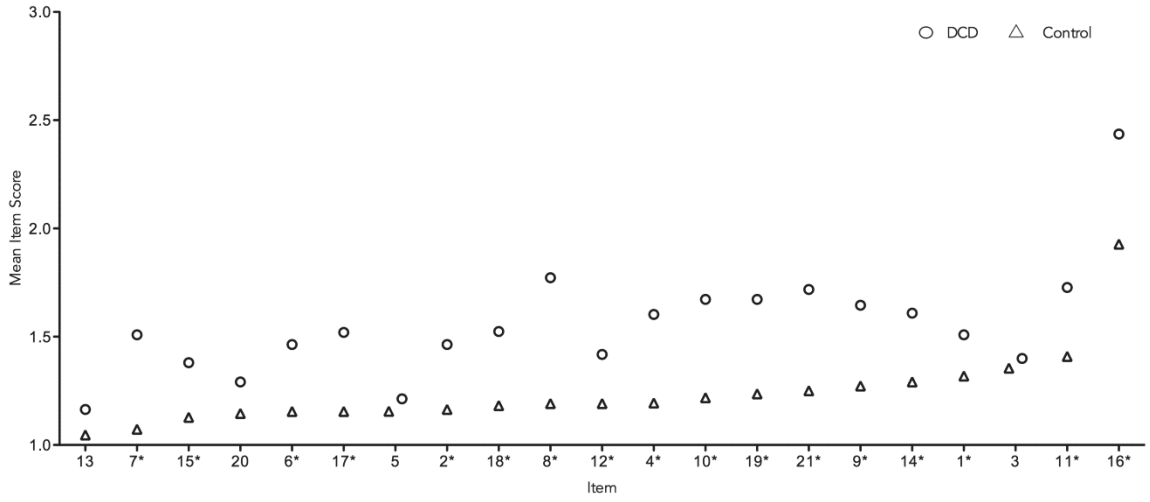

Figure 1. Mean scores on all DCDDaily items for the DCD group and the control group.

Notes: [a] Mean scores for all items are shown for the DCD group (n = 55) and the control group (n = 55), ranked from good to poor, according to the mean scores of the control group; [b] A higher score indicates a worse performance; [c] Items that differentiate between the DCD and the control group, showing a significant difference between mean scores of both groups, are marked with an *; [d] DCD = developmental coordination disorder; SE = standard error; [e] Items: 1 = Buttering a piece of gingerbread, 2 = Cutting a piece of gingerbread, 3 = Opening and closing a lunchbox , 4 = Opening and closing a backpack, 5 = Walking with a chair , 6 = Writing, 7 = Gluing paper using a glue stick, 8 = Folding paper slips, 9 = Colouring a picture, 10 = Cutting paper with scissors, 11 = Lego® building, 12 = Pouring juice, 13 = Walking with a filled cup, 14 = Eating with a spoon, 15 = Opening a package, 16 = Tying shoelaces, 17 = Putting on trousers, 18 = Putting on a polo, 19 = Putting on a body-warmer, 20 = Playing marbles, 21 = Playing hopscotch; [f] See appendix B for the mean scores (SD; range) on all items, for the control group and the DCD group

Final version

An analysis of agreement was performed for the total scores of the *final version* of the DCDDaily, encompassing 18 items, and the current diagnostic criteria for DCD. The area under curve characteristic = 0.872. The receiver-operator characteristics curve is shown in Figure 2. With a cut-off at 24.6, both sensitivity and specificity were found 80%.

Reliability and validity analyses were repeated for the *final version* of the DCDDaily, comprising 18 instead of 21 items: for internal consistency, Cronbach's α = 0.83; for test-retest reliability, the intra-class correlation = 0.90, and for inter-rater reliability, the intra-class correlation = 0.93; for concurrent validity, correlations between mean DCDDaily total scores and mean MABC2 Test percentile scores, MABC2 Checklist total scores, and DCDQ total scores were significant, p = -0.509, p = 0.239, and p = -0.275 (p < 0.001); for discriminant validity, significantly higher mean (SD) DCDDaily total scores were found for the DCD group than for the control group (29 (5.2) versus 22 (4.0), p < 0.001) and for all individual items (ranging p < 0.001-0.005), with the exception of Item 13, "walking with a filled cup" (p = 0.56 for all children in the DCD group and control group (n = 110); p = 0.034 for children six years or older (n = 100)).

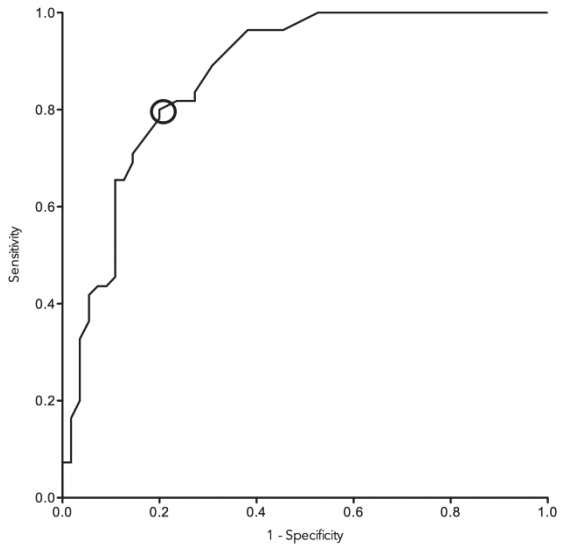

Figure 2. Receiver-operator characteristics (ROC) curve for the DCDDaily total score (18 items), in relation to the current diagnostic criteria for DCD.

Notes: [a] Analyses were performed with DCDDaily total scores of children in the DCD group (n = 55) and their matched controls (n = 55); [b] ROC = Receiver-operator characteristics; for a cut-off at 24.6, sensitivity was found 80% and specificity was found 80%; the area under curve characteristic was found to be 0.872; [c] DCD = developmental coordination disorder

DISCUSSION

The aim of this study was (a) to develop a standardized and objective instrument for clinical assessment of capacity in a broad range of ADL, suitable for children aged five to eight years, with or suspected of having DCD: the DCDDaily; and (b) to investigate the psychometric properties of this new instrument. A thorough review of the literature and extensive communication with experts ensued the design of the DCDDaily to fulfil the specifications set. In the current study, the DCDDaily demonstrated to differentiate between children with and without DCD. Further, the items of the DCDDaily showed high internal consistency and good repeatability, and the DCDDaily demonstrated to be clinically feasible. As expected, a moderate correlation was found between the DCDDaily and the MABC2 Test, that both address different aspects of motor capacity, e.g. capacity in ADL (Criterion B of the diagnostic criteria for DCD) and general motor skills (Criterion A).[1, 16]

The ability of the DCDDaily to differentiate between children with and without DCD was considered the most important element for use in clinical practice. The *research version* of the DCDDaily was able to discriminate between children with and without DCD in 17 of the 21 items. The item "walking with filled cup," did differentiate for the group of children of six years and older. The three other items, "opening and closing a lunchbox," "walking with a chair," and "playing marbles," did not discriminate for any age group and were therefore excluded, resulting in the *final version* of the DCDDaily comprising 18 items. Analyses of reliability and validity were performed on the *final version* of the DCDDaily, as discussed in the following section.

The present data clearly demonstrated the discriminative ability of the DCDDaily. Therefore, it can be used to differentiate between children with and without DCD. Moreover, the sensitivity and specificity of the DCDDaily were good, showing agreement with the current diagnostic criteria for DCD: the DCDDaily correctly identified children diagnosed with DCD and did not identify children in the control group.[35] Further, the internal consistency of the DCDDaily was high and the instrument showed good repeatability: test results were comparable across different moments of testing and across different assessors.[33, 34] The usability of the DCDDaily was also found to be good. The assessment time was limited to 30 minutes and materials are easy-to-use, making the DCDDaily feasible in clinical practice. Moreover, children reported that they understood the principle of simulating "a regular day," and the children and assessors enjoyed the assessments. This is important in supporting the ecological validity of the instrument, reflecting actual daily functioning rather than a forced execution of a set of items. The significant but moderate correlation found between the DCDDaily and the MABC2 Test may be explained by the additional value of the DCDDaily.[2, 37] Both instruments are

standardized and objective clinical tests for assessment of motor capacity, however, different aspects of motor capacity are addressed, i.e. capacity in ADL and general motor skills. The same reasoning holds for the significant but poor correlations found between the DCDDaily and the MABC2 Checklist and the DCDDaily and the DCDQ. Comparison of these instruments demonstrate an important difference between capacity (assessed with a standardized clinical test such as the DCDDaily) and performance (as addressed with questionnaires).[37] Often, what children demonstrate in a standardized test does not reflect what they do in actual daily life according to their parents.[11]

Limitation

Firstly, limitations were found in the study population, although both are in agreement with the DCD population: (a) only a small number of five-year-old children officially diagnosed with DCD were included; and (b) only a small number of females were included in the DCD group. As the diagnostic process is initiated around school age, five-year-old children are often not yet diagnosed.[17] Further, DCD is known to be diagnosed more often in boys than in girls.[38] It is recommended however, to assess more girls and five-year-old children officially diagnosed with DCD, to further investigate the reliability and validity of the DCDDaily in these groups of age and gender. Secondly, test-retest reliability was only analyzed in typically developing children. Comparable results across different moments of testing may not be as likely in children with DCD, as more variation in motor functioning might be expected in the group of children with DCD.[29] In the current study, children with DCD did not perform a retest, as their referral to clinical rehabilitation already involved extensive assessment. In future research, it is considered worthwhile to investigate the test-retest reliability of the DCDDaily in the population it was designed for. Finally, assessors were not blinded to diagnosis, as children were assessed in their own "daily" environment, e.g. a regular primary school (reference group) or at the rehabilitation center where they received intervention (children with DCD). This may have influenced the scores given by the assessors. Bringing children to a location where they could be assessed by blinded assessors was considered too demanding. In future research, however, it may be considered to make videos of assessment which can be scored by blinded assessors afterwards, as this is an important issue.

Future perspectives

For use in clinical practice, the DCDDaily manual contains clear instructions for undertaking the assessment. Norm scores are available for each item to provide clinicians with information about the capacity in ADL of the individual child. In future research, it may be investigated whether the DCDDaily has the ability to support clinicians in setting therapy goals in a valid and reliable way. As the DCDDaily comprises a comprehensive

range of ADL, most difficulties in individual children's daily life might be highlighted. Individualized instruments like Goal Attainment Scaling or the Canadian Occupational Performance Measure might be needed however, to explore all difficulties of individual children with DCD.[39, 40] Finally, possible evaluative abilities of the DCDDaily may be analyzed, as this would add to evaluation of currently used intervention methods, that are focused on children's capacity in ADL, e.g. Cognitive Orientation to Daily Occupational Performance and Neuromotor Task Training.[13, 41-44]

Overall, the DCDDaily is a reliable and valid instrument that provides standardized and objective clinical assessment of children's capacity in ADL. Reliable and valid assessment of Criterion B of the diagnostic criteria for DCD is required, as recommended in the clinical practice guideline for DCD.[1, 2] Used together with the MABC2 Test (Criterion A), the DCDDaily (capacity, Criterion B) and motor questionnaires (performance, Criterion B), may provide complete assessment of the inclusive diagnostic criteria for DCD.[1, 2]

CONCLUSIONS

The DCDDaily provides objective and standardized clinical assessment of children's capacity in a comprehensive range of ADL, relevant to five to eight-year-old children with and without DCD. The DCDDaily is a reliable and valid instrument that is feasible for use in clinical practice.

APPENDICES

Appendix A. DCDDaily items and scoring.

The *research version* of the DCDDaily comprised 21 items. In the *final version*, 3 items were removed, i.e. Opening and closing a lunchbox, Walking with a chair, and Playing marbles.
The *final version* of the DCDDaily comprises the following 18 items: Buttering a piece of gingerbread, Cutting a piece of gingerbread, Opening and closing a backpack, Writing, Gluing paper using a glue stick, Folding paper slips, Colouring a picture, Cutting paper with scissors, Lego® building, Pouring juice, Walking with a filled cup, Eating with a spoon, Opening a package, Tying shoelaces, Putting on trousers, Putting on a polo, Putting on a body-warmer, Playing hopscotch.

Scoring of the items
A success and time score are given for each item. The success score is rated using a 3-point Likert scale, in which 1 = successful, 2 = medium, 3 = poor. In general, 'successful' is marked when the child succeeds on the item and all actions occur fluently. When the child is struggling with one of the actions but eventually succeeds on its own, this is marked 'medium.' 'Poor' is marked when something falls or is knocked over, the child hurts itself or gives up. Finally, the success score is also marked 'poor' when the child exceeds the maximum time (defined per item) as described later on.

The time is measured in seconds and standardized subsequently, based on scores of a normative reference group (n = 404, aged 5 to 8 years). In general, counting time starts when the child touches one of the materials of the relevant item and stops when the activity is completely accomplished. When the child gives up, and a 3 is marked as success score, the measured time score becomes invalid and 'maximum' is filled in as a time score (subsequently standardized into '3'). Also, a maximum amount of time is provided for each specific item as a cut-off for not succeeding. The time score is standardized into a same 3-point Likert scale, in which 1 = successful, 2 = medium, 3 = poor. A time score ≤ (mean + 1 SD) = 1; a score > (mean + 1 SD) and ≤ (mean + 2 SD) = 2; and a score > (mean + 2 SD) = 3.

The item score is calculated as the average of the success score and standardized time score: (success score + time score) / 2. For example, if a child successfully butters a gingerbread (success score = 1), but this takes a relatively long time (> mean + 1 SD, time score = 2), the item score will be "1.5." In cases that an item is not completed successfully, the maximum time score is given and the item score equals the success score, 3. Also in cases that an item exceeds the maximum amount of seconds, the success, time, and item score are marked 3. Finally, for the *research version*, the DCDDaily total score is calculated as the sum of all 21 item scores, ranging 21 (good) to 63 (poor). In the *final version*, the DCDDaily total score is calculated as the sum of all 18 item scores, ranging 18 (good) to 54 (poor).

Table A. Example of an item of the DCDDaily: tying shoelaces.

Description	The child has to tie the shoelaces of one shoe. The child puts on the test shoe. The assessor pulls on the shoelaces and rolls up one pipe of the child's trousers when it blocks the child's vision or movement. The child can start tying the shoelaces
Time score	Start timing when the child touches the shoelaces. Stop timing when the shoelaces are tied Maximum time: 90 seconds
Performance score	
Successful	The child ties the shoelaces easily and fluently (at once)
Medium	The child succeeds in tying the shoelaces, but: - Tying does not occur fluently, or; - The child needs several times to tie.
Poor	The child does not succeed in tying the shoelaces: - The child falls over or hurts itself, or; - The child gives up

Appendix B. Mean scores (SD; range) on the 21 items of the research version of the DCDDaily, for the control group and the DCD group.

	Control group	DCD group
1. Buttering a piece of gingerbread*	1.32 (0.34; 1.0 - 2.5)	1.51 (0.33; 1.0 - 3.0)
2. Cutting a piece of gingerbread*	1.16 (0.27; 1.0 - 2.0)	1.46 (0.49; 1.0 - 3.0)
3. Opening and closing a lunchbox	1.36 (0.50; 1.0 - 3.0)	1.40 (0.62; 1.0 - 3.0)
4. Opening and closing a backpack*	1.19 (0.38; 1.0 - 2.5)	1.60 (0.63; 1.0 - 3.0)
5. Walking with a chair	1.16 (0.34; 1.0 - 2.5)	1.21 (0.46; 1.0 - 3.0)
6. Writing*	1.16 (0.30; 1.0 - 2.0)	1.46 (0.52; 1.0 - 3.0)
7. Gluing paper using a glue stick*	1.07 (0.22; 1.0 - 2.0)	1.51 (0.72; 1.0 - 3.0)
8. Folding paper slips*	1.19 (0.44; 1.0 - 3.0)	1.77 (0.78; 1.0 - 3.0)
9. Colouring a picture*	1.27 (0.53; 1.0 - 3.0)	1.65 (0.72; 1.0 - 3.0)
10. Cutting paper with scissors*	1.22 (0.50; 1.0 - 3.0)	1.67 (0.83; 1.0 - 3.0)
11. Lego® building *	1.41 (0.48; 1.0 - 3.0)	1.73 (0.63; 1.0 - 3.0)
12. Pouring juice*	1.19 (0.37; 1.0 - 2.5)	1.42 (0.43; 1.0 - 2.5)
13. Walking with a filled cup	1.05 (0.17; 1.0 - 2.0)	1.16 (0.37; 1.0 - 3.0)
14. Eating with a spoon*	1.29 (0.38; 1.0 - 2.5)	1.61 (0.48; 1.0 - 3.0)
15. Opening a package*	1.13 (0.35; 1.0 - 3.0)	1.38 (0.61; 1.0 - 3.0)
16. Tying shoelaces*	1.93 (0.90; 1.0 - 3.0)	2.44 (0.84; 1.0 - 3.0)
17. Putting on trousers*	1.16 (0.38; 1.0 - 3.0)	1.52 (0.61; 1.0 - 3.0)
18. Putting on a polo*	1.18 (0.38; 1.0 - 2.5)	1.52 (0.55; 1.0 - 3.0)
19. Putting on a body-warmer*	1.24 (0.44; 1.0 - 3.0)	1.67 (0.55; 1.0 - 3.0)
20. Playing marbles	1.15 (0.36; 1.0 - 2.0)	1.29 (0.53; 1.0 - 3.0)
21. Playing hopscotch*	1.25 (0.45; 1.0 - 3.0)	1.72 (0.58; 1.0 - 3.0)
DCDDaily total score*	26 (4.3; 21-43)	33 (5.6; 25-48)

Notes: [a] Mean scores (SD, range) for all items, for the control group (n = 55) and the DCD group (n = 55); [b] Individual item scores ranged 1 - 1.5 - 2 - 2.5 - 3; the DCDDaily total score could range from 21 to 63; a higher score indicates a worse performance; [c] Items that differentiate between the DCD group and the control group, showing a significant difference between mean scores of both groups, are marked with an *; [d] DCD = developmental coordination disorder

REFERENCES

1. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders: DSM-IV-TR*. American Psychiatric Publishing, Inc.; 2000.

2. Blank R, Smits-Engelsman BCM, Polatajko HJ, Wilson PH. European academy for childhood disability (EACD): Recommendations on the definition, diagnosis and intervention of developmental coordination disorder (long version)*. *Developmental Medicine & Child Neurology.* 2012;54(1):54-93.

3. May-Benson T, Ingolia P, Koomar J. Daily living skills and developmental coordination disorder. In: Cermak SA, Larkin D, eds. *Developmental Coordination Disorder*. Albany, NY: Delmar; 2002.

4. Polatajko HJ, Cantin N. Developmental coordination disorder (dyspraxia): An overview of the state of the art. *Seminars of Pediatric Neurology.* 2005;12(4):250-258.

5. Missiuna C, Moll S, King S, King G, Law M. A trajectory of troubles: Parents' impressions of the impact of developmental coordination disorder. *Physical and Occupational Therapy and Pediatrics*. 2007;27(1):81-101.

6. Geuze RH. Characteristics of DCD: On problems and prognosis. In: Geuze RH, ed. *Developmental Coordination Disorder: A Review of Current Approaches*. Marseille: Solal; 2007.

7. Barnett AL. Motor assessment in developmental coordination disorder: From identification to intervention. *International Journal of Disability, Development and Education*. 2008;55(2):113-129.

8. Larkin D, Rose E. Assessment of developmental coordination disorder. In: Sugden DA, Chambers ME, eds. *Children with Developmental Coordination Dirsorder*. London: Whurr Publishers; 2005.

9. Sugden DA. *Developmental Coordination Disorder as Specific Learning Difficulty*. www.dcd-uk.org. Updated 2006.

10. Magalhaes LC, Cardoso AA, Missiuna C. Activities and participation in children with developmental coordination disorder: A systematic review. *Research in Developmental Disabilities*. 2011;32(4):1309-1316.

11. Holsbeeke L, Ketelaar M, Schoemaker MM, Gorter JW. Capacity, capability, and performance: Different constructs or three of a kind? *Archives of Physical Medicine and Rehabilitation*. 2009;90(5):849-855.

12. World Health Organization. *International Classification of Functioning, Disability and Health: Children & Youth Version*. Geneva: World Health Organization; 2007.

13. Pless M, Carlsson M. Effects of motor skill intervention on developmental coordination disorder: A meta-analysis. *Adapted Physical Activity Quarterly*. 2000;17(4):381-401.

14. Rosenblum S. The development and standardization of the children activity scales (ChAS-P/T) for the early identification of children with developmental coordination disorders. *Child: Care, Health and Development*. 2006;32(6):619-632.

15. Beery KE, Beery NA. *The Beery-Buktenica Developmental Test of Visual-Motor Integration*. Minneapolis, MN: NCS Pearson, Inc.; 2004.

16. Henderson SE, Sugden DA, Barnett AL. *Movement Assessment Battery for Children-2, Examiner's Manual*. London: Pearson Assessment; 2007.

17. Geuze RH, Jongmans MJ, Schoemaker MM, Smits-Engelsman BCM. Clinical and research diagnostic criteria for developmental coordination disorder: A review and discussion. *Human Movement Science*. 2001;20(1):7-47.

18. Geuze RH. Motor impairment in developmental coordination disorder and activities of daily living. In: Sugden DA, Chambers ME, eds. *Children with Developmental Coordination Disorder*. London and Philadelphia: Whurr Publishers; 2005.

19. Josman N, Goffer A, Rosenblum S. Development and standardization of a "do-eat" activity of daily living performance test for children. *American Journal of Occupational Therapy*. 2010;64(1):47-58.

20. Fisher AG, Bryze K, Atchison BT. Naturalistic assessment of functional performance in school settings: Reliability and validity of the school AMPS scales. *Journal of Outcome Measurement*. 2000;4(1):491-512.

21. Fisher AG, Bryze K, Hume V. *SchoolAMPS: School Version of the Assessment of Motor and Process Skills*. Ft Collins, CO: Three Star Press; 2002.

22. Dewey D, Wilson BN. Developmental coordination disorder: What is it? *Physical and Occupational Therapy in Pediatrics*. 2001;20(2/3):5-28.

23. Cermak SA, Gubbay SS, Larkin D. What is developmental coordination disorder? In: Cermak SA,

Larkin D, eds. *Developmental Coordination Disorder*. Albany, NY: Delmar; 2002.

24. Wilson BN, Kaplan BJ, Crawford SG, Campbell A, Dewey D. Reliability and validity of a parent questionnaire on childhood motor skills. *American Journal of Occupational Therapy*. 2000;54(5):484-493.

25. Green D, Bishop T, Wilson BN, Crawford S, Hooper R, Kaplan B, Baird G. Is questionnaire-based screening part of the solution to waiting lists for children with developmental coordination disorder? *The British Journal of Occupational Therapy*. 2005;68(1):2-10.

26. Green D, Lingam R, Mattocks C, Riddoch C, Ness A, Emond A. The risk of reduced physical activity in children with probable developmental coordination disorder: A prospective longitudinal study. *Research in Developmental Disabilities*. 2011;32(4):1332-1342.

27. Wilson PH. Practitioner review: Approaches to assessment and treatment of children with DCD: An evaluative review. *Journal of Child Psychology and Psychiatry*. 2005;46(8):806-823.

28. Reed KL, Sanderson SN. *Concepts of Occupational Therapy*. Baltimore: Williams & Wilkins; 1999.

29. Burton AW, Miller DE. *Movement Skill Assessment*. Human Kinetics Publishers; 1998.

30. Poeck K. The clinical examination for motor apraxia. *Neuropsychologia*. 1986;24(1):129-134.

31. Chaytor N, Schmitter-Edgecombe M, Burr R. Improving the ecological validity of executive functioning assessment. *Archives of Clinical Neuropsychology*. 2006;21(3):217-227.

32. Missiuna C, Pollock N. Beyond the norms. *Physical and Occupational Therapy in Pediatrics*. 1995;15(4):57-74.

33. Shrout PE, Fleiss JL. Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*. 1979;86(2):420.

34. Kline P. *The Handbook of Psychological Testing*. Psychology Press; 2000.

35. Glover TA, Albers CA. Considerations for evaluating universal screening assessments. *Journal of School Psychology*. 2007;45(2):117-135.

36. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977:159-174.

37. Streiner DL, Norman GR. *Health Measurement Scales: A Practical Guide to their Development and use*. Oxford University Press, USA; 2008.

38. Kadesjo B, Gillberg C. Developmental coordination disorder in swedish 7-year-old children. *Journal of the American Academy of Child & Adolescent Psychiatry*. 1999;38(7):820-828.

39. Law M, Baptiste S, Carswell A, McColl MA, Polatajko HJ, Pollock N. *The Canadian Occupational Performance Measure*. 3rd ed. Toronto, ON: CAOT Publications ACE; 1998.

40. Kiresuk TJ, Smith AE, Cardillo JE. *Goal Attainment Scaling: Applications, Theory, and Measurement*. Lawrence Erlbaum Associates, Inc.; 1994.

41. Polatajko HJ, Mandich AD, Miller LT, Macnab J. Cognitive orientation to daily occupational performance (CO-OP): Part II-the evidence. *Physical and Occupational Therapy in Pediatrics*. 2001;20(2/3):83-106.

42. Polatajko HJ, Mandich AD, Missiuna C, Miller LT, Macnab JJ, Malloy-Miller T, Kinsella EA. Cognitive orientation to daily occupational performance (CO-OP): Part III--the protocol in brief. *Physical and Occupational Therapy in Pediatrics*. 2001;20(2-3):107-123.

43. Missiuna C, Mandich AD, Polatajko HJ, Malloy-Miller T. Cognitive orientation to daily occupational performance (CO-OP). *Physical and Occupational Therapy in Pediatrics*. 2001;20(2-3):69-81.

44. Niemeijer AS, Smits-Engelsman BCM, Schoemaker MM. Neuromotor task training for children with developmental coordination disorder: A controlled trial. *Developmental Medicine & Child Neurology*. 2007;49(6):406-411.

DIFFICULTIES IN THE PERFORMANCE OF ACTIVITIES OF DAILY LIVING (ADL) ARE A KEY FEATURE OF DEVELOPMENTAL COORDINATION DISORDER (DCD). THE DCDDAILY-Q WAS DEVELOPED TO ADDRESS CHILDREN'S MOTOR PERFORMANCE IN A COMPREHENSIVE RANGE ADL. THE AIM OF THIS STUDY WAS TO INVESTIGATE THE PSYCHOMETRIC PROPERTIES OF THIS PARENTAL QUESTIONNAIRE. PARENTS OF 218 FIVE TO EIGHT-YEAR-OLD CHILDREN (DCD GROUP: N = 25; REFERENCE GROUP: N = 193) COMPLETED THE RESEARCH VERSION OF THE NEW DCDDAILY-Q AND THE MOVEMENT ASSESSMENT BATTERY FOR CHILDREN-2 (MABC2) CHECKLIST AND DEVELOPMENTAL COORDINATION DISORDER QUESTIONNAIRE (DCDQ). CHILDREN WERE ASSESSED WITH THE MABC2 TEST AND DCDDAILY. ITEM REDUCTION ANALYSES WERE PERFORMED AND RELIABILITY (INTERNAL CONSISTENCY AND FACTOR STRUCTURE) AND CONCURRENT, DISCRIMINANT, AND INCREMENTAL VALIDITY OF THE DCDDAILY-Q WERE INVESTIGATED. THE FINAL VERSION OF THE DCDDAILY-Q COMPRISES 23 ITEMS THAT COVER THREE UNDERLYING FACTORS, AND SHOWS GOOD INTERNAL CONSISTENCY (CRONBACH'S A \ .80). MODERATE CORRELATIONS WERE FOUND BETWEEN THE DCDDAILY-Q AND THE OTHER INSTRUMENTS USED (P / .001 FOR THE REFERENCE GROUP; P /= .05 FOR THE DCD GROUP). DISCRIMINANT VALIDITY OF THE DCDDAILY-Q WAS GOOD FOR DCDDAILY-Q TOTAL SCORES (P / .001) AND ALL 23 ITEM SCORES (P /= .01), INDICATING POORER PERFORMANCE IN THE DCD GROUP. SENSITIVITY (88%) AND SPECIFICITY (92%) WERE GOOD. THE DCDDAILY-Q BETTER PREDICTED DCD THAN CURRENTLY USED QUESTIONNAIRES (R^2 = .88). IN CONCLUSION, THE DCDDAILY-Q IS A VALID AND RELIABLE QUESTIONNAIRE TO ADDRESS CHILDREN'S ADL PERFORMANCE.