Daily functioning in children with developmental coordination disorder

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CHAPTER 2

A SYSTEMATIC REVIEW OF INSTRUMENTS FOR ASSESSMENT OF ADL IN CHILDREN WITH DCD

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A systematic review of instruments for assessment of capacity in activities of daily living
in children with developmental coordination disorder

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INTRODUCTION

Adequate performance in activities of daily living (ADL) is essential for daily functioning.[1] Children with developmental coordination disorder (DCD) have evident motor difficulties in ADL, which has great impact on their daily lives.[2-7] Insight into children's capacity in ADL is essential for clinicians, both to diagnose DCD (Criterion B) and to provide optimal treatment, in order to limit the daily consequences for these children.[3, 8-14] Currently, questionnaires are used to assess Criterion B, providing information on the child's performance, which reflects what a child does during daily life.[15, 16] Although this information is of great worth, standardized and objective assessment is needed to obtain reliable insight into a child's capacity in ADL, reflecting what a child is capable of.[8, 15, 16] It is unknown what instruments are suited for such assessment in children with DCD.[15]

Given the extreme importance of ADL in daily life and the need for assessment of capacity in ADL for diagnosis and intervention of DCD, an overview and evaluation of the available instruments to assess children's motor capacity in ADL is needed. The purpose of this study was to systematically review those instruments that are potentially suitable for standardized and objective assessment of capacity in ADL, in children with or suspected of having DCD.

As a first step, databases were searched to identify studies that described instruments with potential use for assessment of children's motor capacity in ADL (step 1; see Methods). Secondly, instruments were included for review when meeting specified criteria (step 2; see the following paragraphs and Methods). Finally, the suitability of the included instruments for children with DCD was discussed, based on the ADL comprised, and the ecological validity and other psychometric properties of the instruments (step 3; see Results and Discussion).

For step 2, in order to select instruments with potential use for assessment of children's motor capacity in ADL - suitable for children with DCD, three criteria were used. These criteria for inclusion in the current systematic review were for instruments to be standardized and objective (criterion I); to comprise items that reflect ADL (criterion II); and to be applicable to school-aged children that can move independently (criterion III).

Step 2, criterion I. The focus of this review was on standardized and objective instruments only. Both objective instruments, e.g. clinical tests for assessment of motor function, and subjective instruments, e.g. parental and teacher questionnaires, interviews and self-reports to assess ADL, are used in clinical practice, and both provide worthwhile information for intervention planning. However, for diagnosis and evaluation of intervention, objective insight in the child's capacity in the relevant ADL is essential.[3, 17-19] Furthermore, objective assessment of ADL constitutes clinical observation, which

supports the clinicians understanding of the difficulties of the individual child, facilitating optimal treatment.[17]

Step 2, criterion II. Instruments were included for review that comprise items that reflect ADL. In the current study, ADL are defined as "motor-based activities with a functional or meaningful goal that are performed on a daily basis." Instruments were thus included when comprising activities that could be part of a child's daily life, i.e. that might be performed on a daily basis, and having a functional or meaningful goal. For children, three main areas of ADL are distinguished: (a) "self-care and self-maintenance," e.g. mobility, personal hygiene, feeding and dressing; (b) "productivity and schoolwork," e.g. handwriting, crafting and organizing one's desk; and (c) "leisure and play," e.g. ball skills and riding a bike.[2, 3, 8, 9, 22-27] As described in the model of the International Classification of Functioning, Disability and Health (ICF), ADL are part of both the components "activities" and "participation," in which *activities* are described as the execution of a task or action, representing the individuals' perspective or *functioning*.[20] For inclusion in this systematic review, instruments should be objective and assess at "activity level," in order to reflect capacity. Instruments for assessment at the level of participation were therefore excluded. Participation is defined as a person's involvement in a life situation, i.e. with two or more children involved.[20] What children do during actual daily life could at best be assessed by observation or a questionnaire, reflecting performance. As questionnaires are subjective, these are excluded from the current review according to the first criterion.[21] Further, in order to address ADL, assessment of motor function, e.g. speed, strength and sensory-motor integration, is also excluded as this pertains measuring underlying function, not actual daily functioning.[20]

Step 2, criterion III. Instruments should be applicable to school-aged children that can move independently, as these instruments would consider the scope of ADL that is relevant for children with DCD.

Once included, the instruments' comprehensiveness, ecological validity and other psychometric properties are discussed to address the potential use for assessment of capacity in ADL in children with DCD (step 3). Although the instruments should be standardized, assessment of ADL optimally reflects daily functioning when the natural environment of the child is taken into account and the ADL domains of "self-care and self-maintenance," "productivity and schoolwork," and "leisure and play" are included.[3, 22, 28-34]

Summarizing, the objective of this study was to systematically review those instruments that might provide standardized and objective assessment of children's capacity in ADL. When such instruments would be suitable for children with DCD, e.g. comprehensive and ecologically valid, assessment may add to improved diagnosis and intervention, eventually aimed to support clinicians to limit the daily consequences for children with DCD.

METHODS

First, a systematic search of the literature was conducted to identify studies in which instruments were described that might be used to assess ADL in children with developmental motor difficulties (step 1). For the instruments described in these studies, it was evaluated whether they met the criteria for inclusion (step 2), i.e. standardized and objective (criterion I); comprising items that reflect ADL (criterion II); and applicable to school-aged children that can move independently (criterion III). Finally, once instruments were included for review, complementary publications were searched to enable a thorough evaluation of these instruments. Based on the test characteristics as described in the Results section of this chapter, it was evaluated for the included instruments whether they would be applicable for assessment of capacity in ADL in children with DCD, as described in the Discussion section (step 3).

Data Sources and Searches

Comprehensive search terms were chosen in order to assure the inclusion of all studies that described possibly relevant instruments. The search terms used to search the databases of MEDLINE, EMBASE, CINAHL, and PsycINFO were "(Activities of Daily Living) AND (Developmental Coordination Disorder OR clumsiness OR cerebral palsy)." Cerebral palsy was included in the search to expand the investigation to instruments used in more severe motor disorders, that might be applicable to DCD also. The search included articles that were published until November 2011.

A second search was performed to find complementary publications, needed for further evaluation of the included instruments, e.g. psychometric properties. The search terms "(*Name instrument*) AND design OR validity OR reliability" were used to search the databases mentioned above.

Study Selection

All studies found in peer-reviewed journals and published in English as full text articles were included. The studies were selected by two independent reviewers (JN and BL), first by title, then by abstract. To ensure that no potentially useful instruments were missed

beforehand, studies were only excluded when both reviewers proposed so. Finally, the remaining articles were examined full-text. In this step, when the two reviewers did not agree, a third reviewer (MS) was involved to reach consensus.

The reviewers referred a study for inclusion when the instruments described are standardized and objective (criterion I); assess at activity level and comprise items that reflect ADL (criterion II); and are applicable to school-aged children that can move independently (criterion III). Exclusion was proposed when studies described subjective instruments such as questionnaires, self-reports, interviews, scales, or classifications (criterion I); instruments that measure function (e.g. speed, strength, and sensory-motor integration) or participation (criterion II); or instruments developed for infants, pre-school children, or adults, or for children using walking aids or other assistive devices (criterion III).

The selected studies all described one or more instruments that might be used to assess ADL in children. For these instruments, complementary publications were consulted. Subsequently, instruments were excluded from further analysis when (a) the instrument appeared to conflict with the criteria mentioned in the section Study Selection; or (b) a manual or articles describing test goal, ecological validity, clinical use, feasibility, and psychometric properties were not available.

For some instruments, multiple versions were developed over time, e.g. Test Of Motor Impairment (TOMI) [35]; Movement Assessment Battery for Children (MABC) [36]; MABC short-version from the Avon Longitudinal Study of Parents and Children (ALSPAC) [37]; Movement Assessment Battery for Children-2 (MABC2) [31]. In the present study, only the latest and most comprehensive version of an instrument has been evaluated, in this case MABC2.

Data Extraction

For the included instruments, in order to evaluate the suitability of the instruments for children with DCD (step 3), the following characteristics were listed: (a) test goal; (b) test design; (c) the domains of ADL covered; (d) clinical use, i.e. clinical group the instrument was developed for, applicable age range, and clinical goal; (e) assessment time; and (f) psychometric properties, i.e. reliability, validity, and norm scores.

The test goal (a) of an instrument shows which parts of motor performance the instrument aims to assess. This was described to evaluate the applicability of the instruments for ADL assessment. Test design (b) and the domains of ADL covered (c) were described to enable analysis of the ecological validity of the instruments. Activities were included as ADL when both reviewers (JN and BL) reached consensus that the activities: (A) could be part of a child's daily life, i.e. that might be performed on a daily basis; and (B) had a functional or meaningful goal. In case of uncertainty, activities were included, in

order not to miss any. For example, although it occurs every day, transfers from sit to stand are considered not to be meaningful in itself, and were therefore not considered ADL. Consensus was also reached for the inclusion of ADL in the particular domains: home-related activities having to do with personal hygiene, dressing, and feeding were included in the domain of "self-care and self-maintenance," all school-related activities were included in the domain of "productivity and schoolwork," and all play-related activities were included in the domain of "leisure and play." The clinical use (d) of the instruments was described to evaluate the applicability of the instruments for assessment in children with DCD. Assessment time (e) was described to evaluate the feasibility of the instruments. Psychometric properties (f) were investigated to evaluate validity and reliability of the instruments.

RESULTS

Included studies and instruments

The search yielded 1507 potentially relevant publications, of which 1142 remained after removing duplicates, publications that were not full text, e.g. conference abstracts, and articles that were not published in English. After assessment of the titles, 494 articles remained of which abstracts were assessed. Following this, 306 articles were read in full, which resulted in a final selection of 66 articles. The process of article selection is shown in Figure 1.

The remaining 66 studies described 39 instruments for the assessment of ADL in children. For 25 of the instruments, it was clear from the original study that the instrument did not meet the criteria as described in the Methods section of this chapter. These instruments were excluded. A further 5 instruments were excluded because no original publication could be found that described the design or psychometric properties of the instrument. Finally, 2 instruments were not included for further review as these were an early or short version of an instrument already included. This resulted in a total of 7 instruments included for review: the Bruininks-Oseretsky Test of Motor Performance-2 (BOT2) [38], the Do-Eat (Do-Eat) [30], the Movement Assessment Battery for Children-2 (MABC2) [31], the school-Assessment of Motor and Process Skills (schoolAMPS) [39], the Tuffts Assessment of Motor Performance (TAMP) [40], the Test of Gross Motor Development (TGMD) [41], and the Functional Independence Measure for Children (WeeFIM) [42].

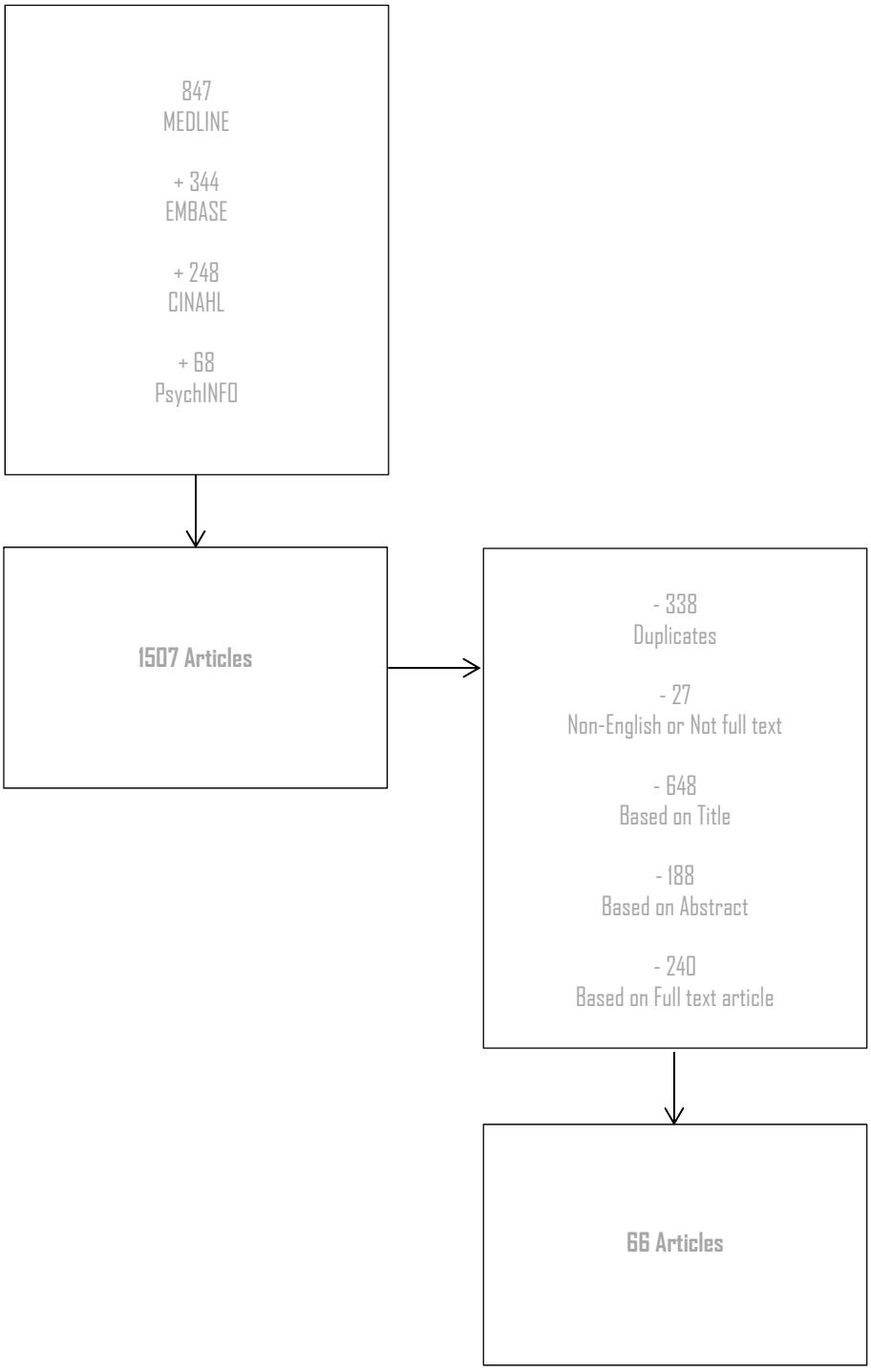

Figure 1. Flowchart of the article selection.

Instrument characteristics

Table 1 shows the seven included instruments with a description of the test goal, test design and the domains of ADL covered. A complete overview of the items per instrument is given in Appendix A. The seven instruments aim for various test goals, such as to measure developmental difficulties, fine and gross motor skills or abilities, functional motor status, school activities, and daily task performance. Three instruments describe ADL assessment as the actual goal of the test: the Do-Eat was designed to measure daily task performance or instrumental ADL, the schoolAMPS measures school activities, and the WeeFIM measures independence at home, in school, and in the community.

The setting in which the assessment takes place, i.e. class room or kitchen, as well as whether items are wrapped up in a logical story to create a natural environment to optimally reflect everyday performance are described by test design. All included instruments are assessed in a natural setting such as a class room, gym, or kitchen (Table 1). However, only the Do-Eat, schoolAMPS, and WeeFIM are assessed in such a way that the setting supports natural performance. The WeeFIM and schoolAMPS provide an observation during actual everyday performance. The items of the Do-Eat are arranged in such a way that they form a natural story. The other instruments include a sequence of separate items only, without a story to support natural performance.

Finally, the number of items that are covered per domain of ADL are shown (Table 1, see also the complete overview of the items per instrument that is given in Appendix A). Three instruments address only one domain of ADL. The schoolAMPS, TGMD, and WeeFIM include items in “productivity and schoolwork,” “leisure and play,” and “self-care and self-maintenance” respectively. The WeeFIM also comprises items that are no motor activities, such as social interaction and problem solving. Two instruments were found to address two domains of ADL, the Do-Eat and TAMP, which both have items in the domains of “self-care and self-maintenance” and “productivity and schoolwork,” but not in “leisure and play.” The TAMP also comprises items that were not considered ADL, such as transfer to mat and sit to supine. Only two instruments were found to address all three domains of ADL, the BOT2 and MABC2. Both tests also comprise items that are not considered ADL, such as standing on one leg and walking with heels raised (MABC2) and touching nose with index fingers, sit-ups, and push-ups (BOT2). Although, for example, standing on one leg can be part of ADL such as putting on trousers, it is not a functional and meaningful daily activity in itself.

Table 1. Instruments included for review, with a description of test goal, test design, and the number of test items per domain of ADL.

Instrument	Test goal [a]	Test design [a]	ADL domains [b]		
			Home	School	Play
1. Bruininks - Oseretsky Test of Motor Performance-2 (BOT2)	Fine and gross motor skills	53 Items of motor performance in 4 areas: fine manual control (15), manual coordination (12), body coordination (16), and strength and agility (10)	4	16	14
2. Do-Eat	Daily task performance / Instrumental Activities of Daily Living	Ecological test in the child's natural surroundings. 3 Tasks: make a sandwich, prepare chocolate milk, and fill out a certificate	2	1	-
3. Movement Assessment Battery for Children-2 (MABC2)	Motor abilities	8 Items in the areas of Manual Dexterity (3), Aiming and Catching (2), and Balance (3)	2	1	3
4. schoolAMPS - Assessment of Motor and Process Skills[†]	School activities	Observation in the classrooms of 2 (out of 25) schoolwork tasks. Performance is rated on 16 school motor and 20 school process skills for each task	-	2	-
5. Tuffts Assessment of Motor Performance (TAMP)	Functional motor status	32 Items in 3 areas, measuring functional and motor component clusters: mobility, ADL, physical aspects of communication	9	4	-
6. Test of Gross Motor Development (TGMD)	Gross motor development	Two subtests with a total of 12 items: Locomotor (6) and Object Control (6)	-	-	12
7. WeeFIM	Developmental difficulties on independence at home, in school, and in the community	Long-term observation of 18 items within 6 domains, considering the level of independence	7	-	-

Notes: [a] Terminology derived from the original studies; [b] The ADL domains "Home," "School," and "Play" are abbreviations of "self-care and self-maintenance," "productivity and schoolwork," and "leisure and play" respectively; [c] ADL = activities of daily living

Table 2 shows descriptive information of the clinical use and assessment time of the included instruments. Some of the reviewed instruments were especially developed for children with DCD (among other disorders), such as the BOT2, Do-Eat, MABC2, and schoolAMPS. Other instruments were originally developed for children with other developmental problems, neurological and musculoskeletal disorders, such as limb deficiencies and cerebral palsy, or for children in special education. The applicable age range of the instruments varies from 6 months to 21 years of age, with one instrument encompassing 15 years (BOT2, 4 to 21 year old children) whereas another instrument encompasses only 1.5 years (Do-Eat, 5 to 6.5 year old children). The clinical goals also differ per instrument. The instruments aim to screen large groups, to identify, discriminate, or diagnose for the disorder they were developed for, to evaluate or monitor the level of motor performance, or a combination of these. Assessment time of the instruments varies from 15 minutes (MABC2, TGMD) to 60 minutes (BOT2, schoolAMPS).

Table 2. Instruments included for review and their clinical use and assessment time.

Instrument	**Clinical use**			**Assessment time**
	Disorder	*Age group*	*Clinical goal*[a]	
1. Bruininks - Oseretsky Test of Motor Performance-2 (BOT2)	DCD, mental retardation, Asperger's syndrome	4-21 years of age	Diagnosis, screening, evaluation	40 to 60 min
2. Do-Eat	DCD	5 to 6.5 years	Evaluation	25 to 30 min
3. Movement Assessment Battery for Children-2 (MABC2)	DCD	3 to 16 years	Discriminative, evaluation	15 to 30 min
4. schoolAMPS - Assessment of Motor and Process Skills[†]	Typically developing or attention-deficit hyperactivity disorder, DCD, learning disability, or sensory integrative disorder	4 to 11 years	Evaluation	30 to 60 min
5. Tuffts Assessment of Motor Performance (TAMP)	Neurologic and musculoskeletal disorders	> 6 years (including adults)	Clinical evaluation	< 1 hour (including break time to optimize performance)
6. Test of Gross Motor Development (TGMD)	Children in special education	3 to 10 years	Identification, screening	15 to 20 min
7. WeeFIM	Limb deficiency, Down's syndrome, spina bifida, cerebral palsy, extreme prematurity	6 months to 7 years	Track and monitor disability status	20 min

Notes: [a] Evaluation = used to evaluate improvement (over time or by intervention) or decline (over time); [b] DCD = developmental coordination disorder

In Table 3, psychometric properties are shown for the reviewed instruments, as far as information was available from the second search. Reliability was found to be moderate to good in all instruments, considering internal consistency, test-retest reliability, and inter-rater reliability. Construct validity was found to be satisfying in all instruments. Concurrent validity varied over the instruments and their different subtests. Norm groups comprised 40 (TAMP) to 1592 (schoolAMPS) children.

Table 3. Psychometric properties of the instruments included for review.

Instrument	Psychometric properties					
	Reliability			*Validity*		*Norm scores*
	Internal Consistency	Test Retest reliability	Inter-rater reliability	Construct (differentiate groups)	Concurrent (correlations other measurements)	
1. Bruininks - Oseretsky Test of Motor Performance-2 (BOT2)	≥0.93	>0.80	>0.90	>0.80, p<0.001	0.51-0.75	1520 children, from USA (distributed), 12 age groups
2. Do-Eat	0.89-0.93	-	0.92	14.09, p<0.001	-0.86, p<0.001	-, children from Israel
3. Movement Assessment Battery for Children-2 (MABC2)	0.92-0.98	0.80	All but one >0.95	-	0.76-0.86	1172 children, from Canada, USA, UK, and validated for other countries
4. schoolAMPS - Assessment of Motor and Process Skills†	-	-	96% of raters demonstrated goodness of fit	0.89, p<0.001	0.35-0.45	1592 children from USA, Australia, and Europe (mostly UK)
5. Tuffts Assessment of Motor Performance (TAMP)	All but one >0.85	-	-	-	-	40 children, -
6. Test of Gross Motor Development (TGMD)	>0.80	>0.88	0.98	-	-	1208 children, from USA (10 states)
7. WeeFIM	0.82-0.94	0.85-0.99	0.73-0.97	-	0.53-0.95	804 children, from USA

Note: When information could not be obtained, "-" is given

DISCUSSION

In the current systematic review, instruments were included that might be of use for standardized and objective assessment of children's capacity in ADL. Seven potentially relevant instruments were found, of which an overview and evaluation is provided in this study: BOT2, Do-Eat, MABC2, schoolAMPS, TAMP, TGMD and WeeFIM. These instruments can be used to assess a variety of goals, such as diagnosis, screening, and evaluation of children in several age ranges and with diverse mild (motor) disorders, such as DCD. In the following sections, the suitability of these single instruments is evaluated for assessment of capacity in ADL in children with DCD. To this end, the instruments should (a) regard the heterogeneity of the disorder, which requires a broad range of activities from the three domains of ADL to be assessed; (b) be ecologically valid, which demands an ecological setting and items that reflect everyday ADL functioning; and (c) have good test characteristics such as feasibility for use in clinical practice and sound psychometric properties. Standardized and objective assessment of capacity in ADL that

fulfills these criteria, can be of great clinical value for diagnosis and intervention in children with DCD.

(a) As DCD is a heterogeneous disorder, it is represented by a wide range of variation in everyday performance.[4, 8, 43] This was recently affirmed by the outcome of parental interviews, that emphasize the diversity of ADL children with DCD face trouble with.[6] Assessment should thus include a comprehensive range of ADL that might be affected in DCD, to cover possible difficulties of individual children with DCD. Consequently, assessment of capacity in ADL should comprise a representative set of items from all three domains of ADL: "self-care and self-maintenance," "productivity and schoolwork," and "leisure and play".[3]

The schoolAMPS, TGMD, and WeeFIM each address only one domain of ADL. The Do-Eat and TAMP both address two domains, but neglect "leisure and play" despite the importance of this domain in children's daily life and the acknowledged problems in this area for children with DCD.[2, 3] Only two instruments were found to address all three domains of ADL, the BOT2 and MABC2. However, the activities covered per domain are limited. In the domain "self-care and self-maintenance," the instruments assess items like threading beads / stringing blocks and posting coins / transferring pennies. Activities of dressing, feeding, and chores are neglected, despite the importance of such activities for independent functioning.[2, 3, 6] In the domain "productivity and school," the MABC2 includes only one item, following a trail with a pencil, and the BOT2 includes cutting, folding, drawing, and coloring. School activities that are not addressed with the BOT2 and MABC2 but that might be affected in children with DCD are for example pasting, handling tools, moving about in the classroom, passing out papers, organizing one's desk, and, most importantly, writing.[2, 3] The domain "leisure and play" is addressed with sorting cards (BOT2), items of jumping and hopping, and ball-related activities such as dribbling, catching, and throwing (BOT2 and MABC2). Activities such as pumping a swing, riding a bike, climbing objects and running games receive no attention, although these were found to be problematic in children with DCD, especially when maintaining one's own "personal body space" is involved.[2, 3] Concluding, the instruments as reviewed in this study do not provide assessment of ADL as comprehensive as needed for children with a heterogeneous disorder such as DCD.

(b) An important feature of standardized and objective ADL assessment is the ecological validity of the instrument.[28-34] First, generalizability of the test results should be considered. When a child is assessed in an environment that is not ecologically valid, the test-performance may not reflect the child's performance

during daily life. A child who feels uncomfortable or nervous, might perform worse during the test than in the typical daily life situation. In contrast, a child might perform better during a test than during daily life due to extra focus and guidance, and less distraction. Considering the generalizability of assessment, everyday performance is best reflected when assessed in a natural and ecological setting.[32, 34] Second, next to the generalizability of the instrument as a whole, the representativeness of the specific tasks is important as these should relate to the child's everyday performance.[28, 30] Therefore, it is important to assess ADL that are performed on a regular basis from all three domains, and to assess these in a way that reflects everyday performance.

Three instruments describe ADL assessment as an actual test goal, the Do-Eat, schoolAMPS, and WeeFIM. Generalizability of these three instruments is taken care of, as a natural environment is provided to support an optimal reflection of the child's everyday performance. Further, the representativeness of the specific tasks is managed with the schoolAMPS and WeeFIM, as the child is being observed during actual home and school activities. The Do-Eat comprises items that are actual ADL as well, i.e. make a sandwich, prepare chocolate milk, and fill out a certificate. For the BOT2, MABC2, TAMP, and TGMD, test designs were not specifically aimed to measure ADL, but to assess functional motor status or fine and gross motor skills, motor abilities, or motor development. Correspondingly, the MABC2 for example, is "a reflection of motor skill rather than an evaluation of activities of daily living".[44] Nevertheless, these instruments do comprise items that reflect ADL, such as drinking, dressing, and writing (TAMP), kicking and rolling a ball (TGMD), handling coins or pennies and ball-related activities (MABC2 and BOT2). The BOT2, MABC2, and TAMP however, do also assess items that are not considered ADL as these are no functional and meaningful daily activities, such as transfer to mat, sit to supine, balancing on one leg, and touching nose with index fingers. Thus, although several ADL can be assessed with the included instruments, only the Do-Eat, schoolAMPS, and WeeFIM provide ecologically valid assessment of ADL.

(c) Test characteristics such as clinical use, feasibility, and psychometric properties (reliability, validity, and norm scores) are discussed for the instruments that were considered to provide ecologically valid ADL assessment: Do-Eat, schoolAMPS, and WeeFIM. The Do-Eat and schoolAMPS were especially developed for children with DCD (among other disorders). The WeeFIM was designed to assess limb deficiencies in children with Down's syndrome, cerebral palsy, and extreme prematurity. The applicability of the WeeFIM for children with DCD should therefore be investigated before use in this area. As DCD is most often diagnosed and treated in school-aged

children, assessment for children in this age range would be optimal.[3] The age range of the schoolAMPS (4 to 11 years of age) suffices. Both the Do-Eat (5 to 6.5 years of age) and WeeFIM (6 months to 7 years of age) have limited applicability to school-aged children. This does not facilitate monitoring of children as they grow into school and receive intervention. Assessment time of the instruments varies from 20 minutes (WeeFIM) and 30 minutes (Do-Eat) to 60 minutes (schoolAMPS). An assessment time of 30 minutes is generally accepted to be feasible in clinical practice. However, as comprehensive assessment of ADL might take more time, 60 minutes was considered an acceptable amount of time. Considering the psychometric properties of the Do-Eat, validity, internal consistency, and inter-rater reliability were found to be good, but data on test-retest reliability were not available in the literature. Further, norm scores are not provided and validation outside the Israelian population is waited for. The schoolAMPS norm scores were based on assessments of 1592 children from various countries, which is satisfactory. Construct validity and inter-rater reliability were found to be good. Data on test-retest reliability were not available. For the WeeFIM, reliability was found to be good. Data on construct validity were not available and the concurrent validity was found variable. Norm scores were based on more than 800 children, which is satisfactory. Concluding, the psychometric properties of the instruments were found to be moderate to good.

In sum, the instruments included in this review enable assessment of capacity in several ADL. The Do-Eat, schoolAMPS, and WeeFIM were found to be the only instruments to provide ecologically valid assessment. However, these instruments address a restricted part of ADL only, which is considered an essential shortcoming for assessment in a heterogeneous disorder such as DCD. Concluding, none of the currently available instruments provide comprehensive and ecologically valid assessment of capacity in ADL as required in the field of DCD.

Study limitations

Since the search was restricted to articles published in English, instruments described in other languages were not included in this review. Also, for some of the reviewed instruments, not all information required could be obtained. The characteristics lacking may never have been investigated, or at least a publication could not be traced. Authors and citations were not explicitly tracked to find more instruments, as the broad search had already delivered 39 instruments, including those that are commonly described in DCD literature. Further, the criteria set to review the included instruments were based on expert consensus, since no guidelines exist to evaluate ADL assessment in children. However, the ADL model was used as extensively described in the literature.[2, 3, 8-10, 22-26]

Further, to mark a certain activity to be ADL or not is a debatable choice as the demands specified leave space for discussion. However, consensus was immediately reached for all items, except threading beads / stringing blocks and posting coins / transferring pennies. These were included after short discussion, because the items represent ADL as defined in this study. For the inclusion of ADL in one of the three domains, consensus was quickly reached as well, although some overlap could not be ruled out. This was not considered a problem as instruments are not used by part; for assessment, complete instruments are used. Finally, several instruments often mentioned in the literature on DCD were excluded from this review because they do not provide standardized and objective assessment of capacity in ADL. These instruments were (a) interviews, questionnaires, or self-reports, e.g. Developmental Coordination Disorder Questionnaire (DCDQ)[45] , Pediatric Evaluation of Disability Inventory (PEDI)[46], Perceived Efficacy and Goal Setting system (PEGS)[24], or scales or classifications, e.g. Functional Mobility Scale (FMS)[47], Gross Motor Function Classification System (GMFCS)[48]; (b) measure function or participation instead of activities (ICF Model)[20], e.g. Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI)[49]; and (c) were not designed for school-aged children, e.g. Peabody Developmental Motor Scales (PDMS)[50], or were developed for children using walking aids or other assistive devices, e.g. Gross Motor Function Measure (GMFM)[51]. Subjective instruments, although not included in this review, are considered of great importance and deserve a review on their own. Subjective instruments have shown results that are closely related to results from objective instruments.[52, 53] Furthermore, parents and teachers might well notice the impact of motor difficulties in a wide range of daily activities, providing information on daily life performance or participation.[5, 54] Subjective information is always necessary as an additional source of information, because standardized and objective assessment can only comprise a limited amount of ADL due to time, spatial, and ethical constrains. Ideally, assessment of capacity in ADL should be part of comprehensive assessment of children with DCD, in which objective observation by a clinician, i.e. capacity in ADL, and subjective information from parents, teachers and the child, i.e. performance in ADL, is combined.[17, 18, 55]

CONCLUSIONS

The current study yielded a comprehensive and well-controlled overview of standardized and objective instruments to assess capacity in ADL in children. The selected instruments were extensively evaluated and no single instrument was found to be satisfactory for assessment of capacity in ADL in children with DCD.

APPENDIX

Appendix A. Items per instrument in the domains of ADL and items that were not considered ADL.

Instrument	ADL domains [a]			Not ADL
	Home	School	Play	
1. Bruininks - Oseretsky Test of Motor Performance-2 (BOT2)	Transferring pennies; Stringing blocks; Stepping over	Filling in shapes (2x); Drawing lines (2x); Connecting or making dots (2x); Folding paper; Cutting out a circle; Copying (8x)	Sorting cards; Jumping or hopping (6x); Dropping, catching, dribbling, throwing a ball (7x)	Placing pegs; Touching nose with index fingers; Pivoting thumbs and index fingers; Tapping feet and fingers (2x); Standing with feet apart or on one leg or heel to toe (8x); Walking on a line (2x); Shuttle run; Push-ups and wall sit (4x)
2. Do-Eat	Make a sandwich; Prepare chocolate milk	Fill out a certificate	-	-
3. Movement Assessment Battery for Children-2 (MABC2)	Threading beads; Posting coins	Following a trail	Catching; Throwing; Jumping	Standing on one leg; Walking with heels raised
4. schoolAMPS - Assessment of Motor and Process Skills [b]	-	Items such as coloring, cutting, and pasting	-	-
5. Tuffts Assessment of Motor Performance (TAMP)	Walking (2x); Stair walking; Pooring; Drinking; Jacket on and off; Zippering; Buttoning; Shoes on and off	Cutting; Writing; Typing; Paper in Envelope	-	Transfer to mat; Sit to suppine; Sit to prone; Prone to quadruped; Quadruped to supine; Supine to long sit; Long sit to short sit; Mat to chair; Propel wheelchair; Sit to stand; Wheelchair ramp; Talking
6. Test of Gross Motor Development (TGMD)	-	-	Running; Galopping; Hopping; Leaping; Jumping; Sliding; Striking, dribbling, catching, kicking, throwing, rolling a ball	-
7. WeeFIM	Eating; Grooming; Bathing; Dressing; Toiletting; Walking; Stair walking	-	-	Transfers; Bladder and bowel management; Comprehension; Expression; Social interaction; Problem solving; Memory

Notes: [a] The ADL domains "Home," "School," and "Play" are abbreviations of "self-care and self-maintenance," "productivity and schoolwork," and "leisure and play" respectively; [b] For the school-AMPS, 2 items are chosen from a list of 25 school-work tasks, all comprising several motor and process skills

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THE MAIN AIM OF THIS STUDY WAS THE DEVELOPMENT OF THE DCDDAILY: AN INSTRUMENT FOR OBJECTIVE AND STANDARDIZED CLINICAL ASSESSMENT OF CAPACITY IN ADL IN CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER (DCD), AND TO INVESTIGATE ITS USABILITY, RELIABILITY, AND VALIDITY. THE DCDDAILY WAS DEVELOPED BASED ON THOROUGH REVIEW OF THE LITERATURE AND EXTENSIVE EXPERT INVOLVEMENT. TO INVESTIGATE THE USABILITY (ASSESSMENT TIME AND FEASIBILITY), RELIABILITY (INTERNAL CONSISTENCY AND REPEATABILITY), AND VALIDITY (CONCURRENT AND DISCRIMINANT VALIDITY) OF THE DCDDAILY, 459 FIVE TO EIGHT-YEAR-OLD CHILDREN (DCD GROUP, N = 55; NORMATIVE REFERENCE GROUP, N = 404) WERE ASSESSED WITH THE DCDDAILY AND THE MOVEMENT ASSESSMENT BATTERY FOR CHILDREN-2 (MABC2) TEST, AND THEIR PARENTS COMPLETED THE MABC2-CHECKLIST AND DEVELOPMENTAL COORDINATION DISORDER QUESTIONNAIRE (DCDQ). IT WAS FOUND THAT ASSESSMENT WITH THE DCDDAILY IS POSSIBLE WITHIN 30 MINUTES AND IN ANY CLINICAL SETTING. FOR INTERNAL CONSISTENCY, CRONBACH'S A = 0.83. INTRA CLASS-CORRELATION (ICC) = 0.87 FOR TEST-RETEST RELIABILITY AND ICC = 0.89 FOR INTER-RATER RELIABILITY. CONCURRENT CORRELATIONS WITH MABC2 TEST AND QUESTIONNAIRES WERE R =.-494,R = 0.239, AND R = -0.284 (P / 0.001). DISCRIMINANT VALIDITY MEASURES DEMONSTRATED SIGNIFICANTLY WORSE PERFORMANCE IN THE DCD GROUP THAN IN THE MATCHED CONTROL GROUP (MEAN (SD) SCORE 33 (5.6) VERSUS 26 (4.3), P / 0.001). THE AREA UNDER CURVE CHARACTERISTIC = 0.872; SENSITIVITY AND SPECIFICITY WERE 80%. IN CONCLUSION, THE DCDDAILY IS A VALID AND RELIABLE INSTRUMENT FOR CLINICAL ASSESSMENT OF CHILDREN'S CAPACITY IN ADL, THAT IS FEASIBLE FOR USE IN CLINICAL PRACTICE.