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

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Abstract

Children with developmental co-ordination disorder (DCD) face evident motor difficulties in activities of daily living (ADL). Assessment of their capacity in ADL is essential for diagnosis and intervention, in order to limit the daily consequences of the disorder. The aim of this study is to systematically review potential instruments for standardized and objective assessment of children's capacity in ADL, suited for children with DCD. As a first step, databases of MEDLINE, EMBASE, CINAHL and PsycINFO were searched to identify studies that described instruments with potential for assessment of capacity in ADL. Second, instruments were included for review when two independent reviewers agreed that the instruments (1) are standardized and objective; (2) assess at activity level and comprise items that reflect ADL; and (3) are applicable to school-aged children that can move independently. Out of 1507 publications, 66 publications were selected, describing 39 instruments. Seven of these instruments were found to fulfil the criteria and were included for review: the Bruininks-Oseretsky Test of Motor Performance-2 (BOT2); the Do-Eat (Do-Eat); the Movement Assessment Battery for Children-2 (MABC2); the school-Assessment of Motor and Process Skills (schoolAMPS); the Tuffts Assessment of Motor Performance (TAMP); the Test of Gross Motor Development (TGMD); and the Functional Independence Measure for Children (WeeFIM). As a third step, for the included instruments, suitability for children with DCD was discussed based on the ADL comprised, ecological validity and other psychometric properties. We concluded that current instruments do not provide comprehensive and ecologically valid assessment of capacity in ADL as required for children with DCD.

Keywords
activities of daily living, assessment, child, motor skill disorders, systematic review

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Introduction

Adequate performance in activities of daily living (ADL) is essential for daily functioning (World Health Organization 2001). Children with developmental co-ordination disorder (DCD) have evident motor difficulties in ADL, which has great impact on their daily lives (May-Benson *et al.* 2002; Polatajko & Cantin 2005; Rosenblum 2006; Sugden 2006; Geuze 2007; Missiuna *et al.* 2007). Insight into children's capacity in ADL is essential for clinicians, both to diagnose DCD (Criterion II) and to provide optimal treatment, in order to limit the daily consequences for these children (American Psychiatric Association & Task Force on DSM-IV 2000; Crawford *et al.* 2001; Cermak *et al.* 2002; Larkin & Rose 2005; Sugden 2006;

Sugden 2007; Barnett 2008; Magalhaes *et al*. 2011). Currently, questionnaires are used to assess Criterion II, providing information on the child's performance, which reflects what a child does during daily life (Holsbeeke *et al*. 2009; Blank *et al*. 2012). 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 (Cermak *et al*. 2002; Holsbeeke *et al*. 2009; Blank *et al*. 2012). It is unknown what instruments are suited for such assessment in children with DCD (Blank *et al*. 2012).

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 is 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 (see Methods). Secondly, instruments were included for review when meeting specified criteria (see the following paragraphs and Methods section). 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 (see Results and Discussion sections).

The criteria for inclusion in the current systematic review (step 2) were for instruments (1) to be standardized and objective; (2) to comprise items that reflect ADL; and (3) to be applicable to school-aged children that can move independently.

Considering criterion 1, the focus of this review is 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 (Missiuna & Pollock 1995; Mandich *et al*. 2003; Sugden 2006; Missiuna *et al*. 2008). Furthermore, objective assessment of ADL constitutes clinical observation, which supports the clinicians understanding of the difficulties of the individual child, facilitating optimal treatment (Missiuna & Pollock 1995).

Considering criterion 2, instruments are reviewed that comprise items that reflect ADL. In the current study, ADL are defined as functional or meaningful activities that are performed during daily life, on a daily basis. As described in the model of the International Classification of Functioning, Disability and Health (ICF), ADL are part of the component 'activities and participation', in which *activities* are described as the execution of a task or action, representing the individuals' perspective or *functioning* (World Health Organization 2007). Objective assessment of *activities* reflects capacity in ADL, whereas questionnaires may be used to assess *participation*, reflecting performance. For inclusion in this systematic review, instruments should thus assess at 'activity level'. Assessment at the level of participation is excluded. Participation is defined as a person's involvement in a life situation, i.e. with two or more children involved (World Health Organization 2007). What a child does during actual daily life, reflecting performance, could at best be assessed by observation or a questionnaire. As questionnaires are subjective, these are excluded according to criterion 1 (Green *et al*. 2005). Further, 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 (World Health Organization 2007).

For children, three main areas of ADL are distinguished: (1) 'self-care and self-maintenance', e.g. mobility, personal hygiene, feeding and dressing; (2) 'productivity and schoolwork', e.g. handwriting, crafting and organizing one's desk; and (3) 'leisure and play', e.g. ball skills and riding a bike (Canadian Association of Occupational Therapists 1991; American Occupational Therapy Association 1994; Law *et al*. 1998; Reed & Sanderson 1999; Cermak *et al*. 2002; May-Benson *et al*. 2002; Dunford *et al*. 2005; Missiuna *et al*. 2006; Sugden 2006, 2007). Considering items to reflect ADL, instruments were included 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.

Considering criterion 3, 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 (Poeck 1986; Reed & Sanderson 1999; Chaytor & Schmitter-Edgecombe 2003; Kvavilashvili & Ellis 2004; Chaytor *et al*. 2006; Sugden 2006; Henderson *et al*. 2007; Kirby & Sugden 2007; Josman *et al*. 2010).

Summarizing the objective of this study is to systematically review those instruments that might provide standardized and objective assessment of children's capacity in ADL. When such instruments would be suited for children with DCD, e.g. comprehensive and ecologically valid, assessment may add to improved diagnosis and intervention, which supports 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, i.e. instruments that (1) are standardized and objective; (2) comprise items that reflect ADL; and (3) are applicable to school-aged children that can move independently (step 2).

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, 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 used possibly relevant instruments (step 1). 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, which 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 (JvN and BvdL), first by title, than 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 (1) are standardized and objective; (2) assess at activity level and comprise items that reflect ADL; and (3) are applicable to school-aged children that can move independently (step 2). Exclusion was proposed when studies described (1) subjective instruments such as questionnaires, self-reports, interviews, scales or classifications; (2) instruments that measure function (e.g. speed, strength and sensory-motor integration) or participation; and (3) instruments developed for infants, pre-school children or adults, or for children using walking aids or other assistive devices.

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 (1) the instrument appeared to conflict with the criteria mentioned in the section Study Selection; or (2) 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, Stott *et al.* 1984); Movement Assessment Battery for Children (MABC, Henderson & Sugden 1992); MABC short-version from the Avon Longitudinal Study of Parents and Children (ALSPAC, Golding *et al.* 2001); Movement Assessment Battery for Children-2 (MABC2, Henderson *et al.* 2007). 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: (1) test goal; (2) test design; (3) the domains of ADL covered; (4) clinical use, i.e. clinical group the instrument was developed for, applicable age range and clinical goal; (5) assessment time; and (6) psychometric properties, i.e. reliability, validity and norm scores.

The test goal (1) 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 (2) and the domains of ADL covered (3) were described to enable analysis of the ecological validity of the instruments. Activities were included as ADL when both reviewers reached consensus that the activities: (i) could be part of a child's daily life, i.e. that might be performed on a daily basis; and (ii) 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, a transfer from sit to stand was considered not to be meaningful in itself, and is therefore not included 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', school-related activities were included in the domain of 'productivity and schoolwork', and play-related activities were included in the domain of 'leisure and play'. The clinical use (4) of the instruments was described to evaluate the applicability of the instruments for assessment in children with DCD. Assessment time (5) was described to evaluate the feasibility of the instruments. Psychometric properties (6) 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 Fig. 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 article. These instruments were excluded. A further five instruments were excluded because no original publication could be found that described the design or psychometric properties of the instrument. Finally, two 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 seven

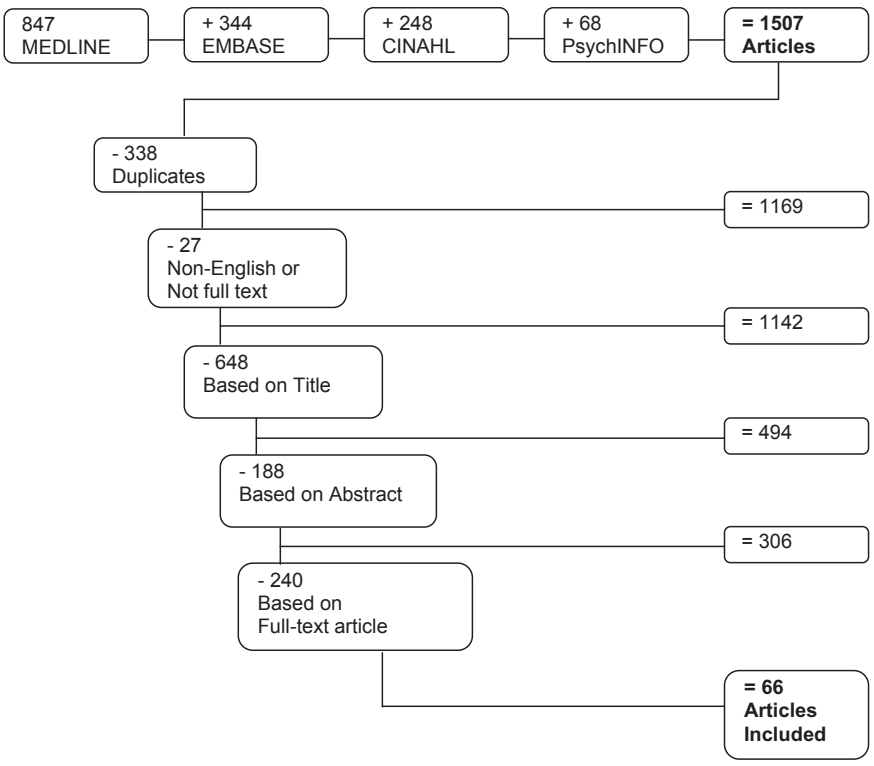

Figure 1. Flowchart of the article selection.

instruments included for review: the Bruininks-Oseretsky Test of Motor Performance-2 (BOT2, Bruininks & Bruininks 2005), the Do-Eat (Do-Eat, Josman *et al.* 2010), the Movement Assessment Battery for Children-2 (MABC2, Henderson *et al.* 2007), the school-Assessment of Motor and Process Skills (schoolAMPS, Fisher *et al.* 2002), the Tuffts Assessment of Motor Performance (TAMP, Gans *et al.* 1988), the Test of Gross Motor Development (TGMD, Ullrich & Sanford 1985) and the Functional Independence Measure for Children (WeeFIM, Msall *et al.* 1994).

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 1. 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 1). 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'

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

			ADL domains†		
Instrument	**Test goal***	**Test design***	**Home**	**School**	**Play**
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 co-ordination (12), body co-ordination (16) and strength and agility (10)	4	16	14
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	–
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
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	–
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	–
Test of Gross Motor Development (TGMD)	Gross motor development	Two subtests with a total of 12 items: Locomotor (6) and Object Control (6)	–	–	12
Functional Independence Measure for Children (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	–	–

*Terminology derived from the original studies.

†The ADL domains Home, School and Play are abbreviations of 'self-care and self-maintenance', 'productivity and schoolwork' and 'leisure and play' respectively.

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

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

*Evaluation: used to evaluate improvement (over time or by intervention) or decline (over time).
DCD, developmental co-ordination disorder.

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 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 min (MABC2, TGMD) to 60 min (BOT2, schoolAMPS).

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.

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 (1) regard the

Table 3. Psychometric properties of the instruments included for review

	Psychometric properties					
	Reliability			***Validity***		
Instrument	**Internal consistency**	**Test–retest reliability**	**Inter-rater reliability**	**Construct (differentiate groups)**	**Concurrent (correlations other measurements)**	**Norm scores**
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 the USA (distributed), 12 age groups
Do-Eat	0.89–0.93	–	0.92	14.09, $P < 0.001$	–0.86, $P < 0.001$	–, children from Israel
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, the USA, the UK, and validated for other countries
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 the USA, Australia and Europe (mostly the UK)
Tuffts Assessment of Motor Performance (TAMP)	All but one >0.85	–	–	–	–	40 children, –
Test of Gross Motor Development (TGMD)	>0.80	>0.88	0.98	–	–	1208 children, from USA (10 states)
Functional Independence Measure for Children (WeeFIM)	0.82–0.94	0.85–0.99	0.73–0.97		0.53–0.95	804 children, from the USA

When information could not be obtained, a '–' is given.

heterogeneity of the disorder, which requires a broad range of activities from the three domains of ADL to be assessed; (2) be ecologically valid, which demands an ecological setting and items that reflect everyday ADL functioning; and (3) have good test characteristics such as clinical use, feasibility and psychometric properties. Standardized and objective assessment of capacity in ADL that fulfils these criteria, can be of great clinical value for diagnosis and intervention in children with DCD.

(1) As DCD is a heterogeneous disorder, it is represented by a wide range of variation in everyday performance (Dewey & Wilson 2001; Cermak *et al.* 2002; Polatajko & Cantin 2005). This was recently affirmed by the outcome of parental interviews, which emphasizes the diversity of ADL children with DCD face trouble with (Missiuna *et al.* 2007). 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' (Sugden 2006). 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 (May-Benson *et al.* 2002; Sugden 2006). Only two instruments were found that 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 (May-Benson *et al.* 2002; Sugden 2006; Missiuna *et al.* 2007). 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 colouring. 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 (May-Benson *et al.* 2002; Sugden 2006). 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 (May-Benson *et al*. 2002; Sugden 2006). 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.

(2) An important feature of standardized and objective ADL assessment is the ecological validity of the instrument (Poeck 1986; Chaytor & Schmitter-Edgecombe 2003; Kvavilashvili & Ellis 2004; Chaytor *et al*. 2006; Henderson *et al*. 2007; Kirby & Sugden 2007; Josman *et al*. 2010). 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 because of 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 (Poeck 1986; Chaytor & Schmitter-Edgecombe 2003). 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 (Kvavilashvili & Ellis 2004; Josman *et al*. 2010). 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' (Geuze 2005). 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.

(3) 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 (Sugden 2006). The age range of the schoolAMPS (4–11 years of age) suffices; however, both the Do-Eat (5–6.5 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 min (WeeFIM) and 30 min (Do-Eat) to 60 min (schoolAMPS). An assessment time of 30 min is generally accepted as feasible in clinical practice. However, as comprehensive assessment of ADL might take more time, 60 min 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 Israeli 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. 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 for DCD.

Study limitations

As 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, as no guidelines exist to evaluate ADL assessment in children. However, the ADL model was used as extensively described in the literature (Canadian Association of Occupational Therapists 1991; Law *et al.* 1998; Reed & Sanderson 1999; American Psychiatric Association & Task Force on DSM-IV 2000; Cermak *et al.* 2002; May-Benson *et al.* 2002; Dunford *et al.* 2005; Missiuna *et al.* 2006; Sugden 2006; Sugden 2007). 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 found in the search and 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 (1) were interviews, questionnaires or self-reports, e.g. Developmental Coordination Disorder Questionnaire (DCDQ, Wilson *et al.* 2000), Pediatric Evaluation of Disability Inventory (PEDI, Haley *et al.* 1992), Perceived Efficacy and Goal Setting system (PEGS, Dunford *et al.* 2005), or scales or classifications, e.g. Functional Mobility Scale (FMS, Harvey *et al.* 2010), Gross Motor Function Classification System (GMFCS, Palisano *et al.* 1997); (2) measure function or participation instead of activities (ICF Model), e.g. Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI, Beery & Beery 2004); or (3) were not designed for school-aged children, e.g. Peabody Developmental Motor Scales (PDMS, Folio & Fewell 2000), or were developed for children using walking aids or other assistive devices, e.g. Gross Motor Function Measure (GMFM, Russell *et al.* 2002).

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 (Bodnarchuk & Eaton 2004; Morris *et al.* 2004). Furthermore, parents and teachers might well notice the impact of motor difficulties in a wide range of daily activities, providing information on participation (Larkin & Cermak 2002; Rosenblum 2006). Finally, subjective information is always necessary as an additional source of information, because standardized and objective assessment can only comprise a limited amount of ADL because of 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 (Missiuna & Pollock 1995; Wilson 2005; Missiuna *et al.* 2008).

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. The instruments as included in this review do provide insight into the child's capacity at activity level, providing information for clinical practice and scientific research of DCD. A standardized and objective instrument for assessment of children's capacity in ADL is needed however, which comprises a broad range of representative and generalizable activities, in order to provide a complete picture of the child's daily functioning. Such an instrument for assessment of capacity in ADL would enable improved diagnosis and intervention planning and evaluation for children with DCD. Assessment of ADL can thus help clinicians to limit the daily consequences of DCD, which is of great importance for the child's daily functioning (World Health Organization 2001).

Key messages

- Assessment of capacity in ADL is essential for diagnosis and intervention of DCD, in order to limit the daily consequences of the disorder.
- Current instruments that are standardized and objective are not suited for comprehensive and ecologically valid assessment of capacity in ADL in children with DCD.

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Appendix 1

Table A1. Items per instrument in the domains of activities of daily living (ADL) and items that are not ADL

	ADL domains*			
Instrument	**Home**	**School**	**Play**	**Not ADL**
Bruininks-Oseretsky Test of Motor Performance-2 (BOT2)	Transferring pennies; Stringing blocks; Stepping over	Filling in shapes (2×); Drawing lines (2×); Connecting or making dots (2×); Folding paper; Cutting out a circle; Copying (8×)	Sorting cards; Jumping or hopping (6×); Dropping, catching, dribbling, throwing a ball (7×)	Placing pegs; Touching nose with index fingers; Pivoting thumbs and index fingers; Tapping feet and fingers (2×); Standing with feet apart or on one leg or heel to toe (8×); Walking on a line (2×); Shuttle run; Push-ups and wall sit (4×)
Do-Eat	Make a sandwich; Prepare chocolate milk	Fill out a certificate	–	–
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
schoolAMPS – Assessment of Motor and Process Skills†	–	Items such as colouring, cutting and pasting	–	–
Tuffts Assessment of Motor Performance (TAMP)	Walking (2×); 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 supine; 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
Test of Gross Motor Development (TGMD)	–	–	Running; Galopping; Hopping; Leaping; Jumping; Sliding; Striking, dribbling, catching, kicking, throwing, rolling a ball	–
Functional Independence Measure for Children (WeeFIM)	Eating; Grooming; Bathing; Dressing; Toileting; Walking; Stair walking	–	–	Transfers; Bladder and bowel management; Comprehension; Expression; Social interaction; Problem solving; Memory

*The ADL domains Home, School and Play are abbreviations of 'self-care and self-maintenance', 'productivity and schoolwork' and 'leisure and play' respectively.
†For the schoolAMPS, two items are chosen from a list of 25 school-work tasks, all comprising several motor and process skills.