Research in Developmental Disabilities 84 (2019) 28–35

Contents lists available at ScienceDirect

Research in Developmental Disabilities

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

Age-related validity and reliability of the Dutch Little Developmental Coordination Disorder Questionnaire (LDCDQ-NL)

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ARTICLE INFO

Number of reviews completed is 2

Keywords:
Little Developmental Coordination Disorder Questionnaire
Developmental Coordination Disorder
Screening
Early childhood
Psychometric properties

ABSTRACT

Background: Early recognition of children at risk of Developmental Coordination Disorder (DCD) is important, but variability in motor development in preschool children affects the validity of instruments to reliably detect children at risk of DCD.
Aims: To investigate the age-related validity and reliability of the Dutch version of the Little Developmental Coordination Disorder Questionnaire (LDCDQ-NL).
Methods and procedures: Two hundred and sixty 3- to 5-year old children were recruited in the Netherlands. Parents filled out the LDCDQ-NL and children were assessed with the Movement Assessment Battery for Children-2 Test (MABC-2 Test). Internal consistency of the LDCDQ-NL was determined by Cronbach's alpha. Construct validity was investigated using factor analysis. Concurrent validity was measured by calculating correlations between the LDCDQ-NL and MABC-2. Receiver Operating Characteristics (ROC) were calculated to assess discriminant validity.
Outcomes and results: Internal consistency of the LDCDQ-NL was 0.91. Factor analysis resulted in three factors (Fine motor skills, Locomotor skills, Ball skills). Correlation between the LDCDQ-NL and MABC-2 Test increased with increasing age. With a sensitivity of 80%, specificity increased with age.
Conclusions and implications: The LDCDQ-NL is a reliable and valid screening instrument for 4- and 5-year old Dutch children; concurrent and discriminant validity are low for 3-year olds.

What this paper adds?

The significance of this study lies in its focus on age-related differences in concurrent and discriminant validity of the Dutch version of the Little DCDQ (LDCDQ-NL). Early recognition of children at risk of DCD is often stressed. However, this is hampered by the variability in motor development during the preschool years. The present study demonstrated that the correlation between the LDCDQ-NL and the MABC-2 Test indeed increases with age as well as the ability of the questionnaire to discriminate between typically developing (TD) children and children at risk of DCD. This implies that total scores on the LDCDQ-NL need to be interpreted with caution in 3-year old children. The results regarding 5-year old children are similar to those of older children. The current results support the recommendation of the European Academy of Childhood Disability that to diagnose DCD under the age of 5, consecutive assessments are required to control for the age-related variation of growth and behavior.

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https://doi.org/10.1016/j.ridd.2018.02.010
Received 24 July 2017; Received in revised form 29 January 2018; Accepted 12 February 2018
Available online 21 February 2018
0891-4222/

1. Introduction

The preschool years are known as the 'golden age' of motor development as most of the fundamental motor skills such as running, jumping, throwing, and catching are developed during these years (Figueroa & An, 2017). Early motor development is often taken for granted, but the reality is that the motor skills of some preschool children are less proficient, interfering with successful participation at home, at preschool, or on the playground. These difficulties could be a first symptom of Developmental Coordination Disorder (DCD; American Psychiatric Association (APA), 2013). The main features of DCD are problems with coordination of fine or gross motor tasks resulting in impairment in activities of daily living either at home or at school in the absence of a detectable neurological condition (APA, 2013). Its origin and aetiology remain a matter of debate, but it is largely agreed that it is a long-term condition (Cairney, Hay, Veldhuizen, Missiuna, & Faught, 2010; Cantell, Smyth, & Ahonen, 2003; Kirby, Sugden, Beveridge, Edwards, & Edwards, 2008).

DCD is commonly only identified and diagnosed at or after the age of 5 years when the motor problems become more noticeable by the structured demands of the school and home environment (Blank, Smits-Engelsman, Polatajko, & Wilson, 2012). Before five years of age diagnosis is not recommended by the European Academy of Childhood Disability (EACD; Blank et al., 2012). The main reason is that children's motor development during the preschool years is characterized by intra-individual variability (Darrah, Senthilselvan, & Magill-Evans, 2009). Discrete assessments of gross and fine motor skills with motor tests do not enable ongoing observation of daily activities and often lack stability, as children may catch up or fall behind in motor performance at different measurement occasions (Darrah et al., 2009). Performance in the clinical range at one particular moment in time does not have to be a cause of concern, but can reflect a temporary plateau in development after which an improvement in performance will emerge. Variability in motor development may be multi-causal as both individual, for example lack of attention or motivation, as well as environmental factors, such as opportunities to practice motor skills, influence development (Darrah et al., 2009; Sugden & Wade, 2013).

Despite the large variability in early motor development, motor problems may be persistent (Eldred & Darrah, 2010) and predictive of DCD (Van Waelvelde, Oostra, Dewitte, Van Den Broeck, & Jongmans, 2010). Some children who present with symptoms of DCD early in childhood are characterized by a trajectory of atypical development, such that the child will be significantly behind in motor development compared to his/her typically developing peers at all points in development from early childhood through adolescence into adulthood (Cairney & King-Dowling, 2016). In addition, children's motor proficiency may have important implications for their cognitive and social development (Diamond, 2007). For example, both gross and fine motor performance are associated with executive functioning (EF) during the preschool years (Oberer, Gashaj, & Roebers, 2017). Moreover, recent research has shown that deficits in EF are already present in preschool children with motor coordination difficulties (Houwen, van der Veer, Visser, & Cantell, 2017). Psychosocial functioning is also affected in young children with DCD (or poor motor skills) (Bart, Hajami, & Bar-Haim, 2007; Piek, Bradbury, Elsley, & Tate, 2008). In sum, longitudinal and cross-sectional research informs us that motor problems and secondary consequences in early childhood can persist through childhood and into adolescence and adulthood in children with DCD. To prevent these problems, early recognition of DCD seems to be paramount in order to give the child the necessary support (Piek, Hands, & Licari, 2012).

To tackle the need for early identification, the Little Developmental Coordination Disorder Questionnaire (LDCDQ) was developed in Israel to screen motor coordination difficulties that may be consistent with 'a risk of DCD in young children' (Rihtman, Wilson, & Parush, 2011). Its psychometric investigation is in progress in several countries and the results look promising (Rihtman et al., 2011, 2013; Venter, Pienaar, & Coetzee, 2015; Wilson et al., 2015). The first aim of the present study was to pursue the examination of the psychometric properties in a Dutch sample of typically developing children and a sample of children at risk of DCD. However, a topic not addressed by previous studies is the age-related variation in two aspects of the validity of the LDCDQ, more specifically, concurrent and discriminant validity. Concurrent validity refers to the relation between scores on two instruments developed to monitor motor development, that is, the LDCDQ and the Movement Assessment Battery for Children –2 Test (MABC-2 Test; Henderson, Sugden & Barnett, 2007). Discriminant validity is considered very important for screening tools and refers to the ability of a test/questionnaire to discriminate between children with and without risk for DCD (Schoemaker, Smits-Engelsman & Jongmans, 2003). Investigation of the age-related differences in concurrent and discriminant validity are particularly relevant considering the need for early identification of children at risk of DCD.

At present, we do not know from which age onwards the LDCDQ can be reliably used as a screening tool. The large variability in motor development in the preschool years may result in too many false positives. For that reason, we decided to study age-related differences in concurrent and discriminant validity in a sample of 3- to 5-year old children. Although the LDCDQ was originally developed for children below five years of age, we decided to also include 5-year old children in the present study. In the Netherlands, the preschool period ends when children go to the third grade at approximately 6 years of age. In addition, many of the skills included in the items of the LDCDQ are still relevant for 5-year old children. By including 3- to 5-year old children, we were able to assess whether results regarding concurrent and discriminant validity are indeed better for 5-year old children than for 3- and 4-year old children, which would support the recommendation of the EACD not to diagnose DCD before the age of 5 (Blank et al., 2012).

To summarize, the first aim of the current study was to further investigate the psychometric properties of the LDCDQ by carrying out appropriate validity and reliability analyses for 3- to 5-year old children in a community sample and a sample at risk of DCD in the Netherlands. The second aim of this study was to investigate the concurrent and discriminant validity of the LDCDQ-NL for 3-, 4-, and 5-year old children separately to assess whether this instrument can be reliably used in each age group.

2. Method

2.1. Participants

A convenience sample of 260 preschool children and their parents/caregivers was recruited in the North of the Netherlands. Participants were recruited from kindergartens, day-care centres, and public swimming pools.[1] In addition, paediatric physical therapy practices were approached to recruit children who were referred to therapy due to atypical motor development. To be included, the age of the children had to be between 3 years 0 months and 5 years 11 months, and their parents/caregivers had to have a good understanding of the Dutch language. The exclusion criteria were used to confirm that coordination difficulties did not relate to a medical condition or disease (e.g., cerebral palsy, muscular dystrophy, visual impairment or intellectual disability). The sample consisted of 90 three-year old children (45 males; 50%), 92 four year old children (44 males; 48%), and 78 five year old children (46 males; 59%). Based upon the MABC-2-NL Test (Henderson, Sugden, Barnett, & Smits-Engelsman, 2010) data children were divided into two groups, a group of 172 typically developing children (TD group) with percentile scores on the MABC-2-NL Test above the 16th percentile and a group of 88 children at risk of DCD (at-risk group) with scores at or below the 16th percentile. Of the 31 children recruited via the paediatric physiotherapists, 21 scored at or below the 16th percentile on the MABC-2-NL Test (*M* 15.5, *SD* 17.2). Parental education was classified based on mother's education into three groups: Low educational level (primary school and lower secondary education; 4%); Intermediate educational level (intermediate vocational level, higher secondary school and pre university education; 22%); High educational level (higher vocational education and university; 62%). Educational information was missing from 12% of the mothers.

2.2. Measures

The measures included two instruments developed to monitor motor development and a sociodemographic questionnaire developed to collect background information such as parental education.

2.2.1. Little Developmental Coordination Disorder Questionnaire (LDCDQ)

The LDCDQ is a low cost and easy to complete parental questionnaire that has been developed to screen for motor coordination difficulties of 3- and 4-year old children. A forward-backward translation procedure was applied to develop the Dutch version, the LDCDQ-NL. One of the original items which includes examples of culture specific children's games was adapted to better match similar kinds of Dutch children's games. The questionnaire consists of 15 items which are divided into three sub-categories, consisting of five items in each: control during movement, fine motor and general coordination. For each item, parents are asked to compare the performance of their child with that of children of the same age and gender, and to rate their performance on a 5-point Likert scale, with 1 = not at all relevant to my child to 5 = extremely relevant for my child. Each sub-category has a maximum score of 25. A total score (maximum = 75) is composed by adding the individual item scores, with higher scores indicating a higher level of motor proficiency.

The validity and reliability of the different language versions of the LDCDQ were considered to be good (Rihtman et al., 2011; Venter et al., 2015; Wilson et al., 2015). More specifically, the reliability of the LDCDQ, reported as correlation coefficients (ICCs), was acceptable to high (ICC 0.67–0.98) and it had a significant and good test-retest reliability (0.80–0.90). The total scores of the LDCDQ and the MABC-2 Test were moderately correlated (r = 0.29–0.30). Furthermore, in the study of Wilson et al. (2015), the sensitivity of the LDCDQ ranged from 80% to 86% and specificity from 49% to 63%. In the study of Venter et al. (2015), a cross-tabulation of the LDCDQ and M-ABC showed that the sensitivity was 57% and specificity 81%.

2.2.2. Movement Assessment Battery for Children-2nd edition (MABC-2 Test)

The MABC-2 Test is a standardized test to identify motor problems in children between 3 and 16 years of age (Henderson et al., 2007). The test consists of three age bands, of which only the first (3–6 years) was used in the present study. Each age band consists of 8 items, in which manual dexterity, aiming and catching, and static and dynamic balance are assessed. Raw scores on each item are transformed into standard scores. The total test score is the sum of the eight item standard scores. The total test score can be converted into percentile ranks which indicate the level of performance of a child compared to the normative sample. Scores above the 16th percentile indicate typical motor development, scores between the 5th and 16th percentile indicate that a child is at risk of motor impairment, and scores below the 5th percentile indicate motor impairment. In the present study, the Dutch version of the MABC-2 Test (MABC-2-NL Test) was used (Henderson, Sugden, Barnett, & Smits-Engelsman, 2010). Smits-Engelsman, Niemeijer, and van Waelvelde (2011) suggest that 3-year old children can be formally and reliably tested with the MABC-2 Test and that it can be applied to assess motor performance in typically developing 3-year old children.

2.3. Procedure

Ethical approval was acquired from the Ethics Committee of the Department of Pedagogical and Educational Sciences, Faculty of

[1] Children's swimming classes are a common practice in the Netherlands due to national water safety guidelines and due to subsidies most children get a basic diploma.

Behavioural and Social Sciences, University of Groningen, the Netherlands. Written consent was obtained from the parents/caregivers.

Parents filled out the LDCDQ-NL at home while their child was assessed with the MABC-2-NL Test. The testers were masters level students in special education or psychology and were trained a minimum of 20 h to test administration. All assessments were videotaped to double check scoring and ensure reliability.

2.4. Data analysis

The data were entered and analysed with IBM Statistical Package for Social Science version 23 (SPSS-23) to examine the psychometric properties of the LDCDQ-NL. In order to investigate the internal consistency of the LDCDQ-NL items, Cronbach's alpha and item-to-total correlations were computed. An alpha level above 0.70 was considered acceptable (Bland & Altman, 1997). The item correlation with the total score was set above 0.20 (Streiner & Norman, 2008).

An ANOVA was carried out to investigate the effects both for the whole group and for the separate gender and age groups. A factor analysis (principal components with varimax rotation) was carried out on the LDCDQ-NL to explore its factor structure both for the whole group, gender and for the separate age groups. A factor loading above 0.30 was determined to be an acceptable level to include a particular item into a factor (Tabachnick & Fidell, 2014). We opted for Principal Component Analysis with Varimax rotation to be able to compare the results across studies as the same method was used in the study by Wilson et al. (2015).

In order to assess concurrent validity, Pearson correlations were calculated between the LDCDQ-NL and the MABC-2-NL Test. Cohen's (1988) guidelines were used to interpret the calculated correlation coefficients. Correlation coefficients lower than 0.1 were considered as insubstantial, between 0.3 and 0.1 as low, between 0.5 and 0.3 as moderate and above 0.5 as high. To measure discriminant validity, an ANOVA was carried out to compare the mean total LDCDQ-NL scores of the TD group with the mean total scores of the at risk group. Independent sample *t*-tests were carried out to compare the mean total LDCDQ-NL scores of the TD group with the mean total scores of the at risk group for each age group separately. Receiver Operating Curves (ROC) were calculated to determine cut-off points that lead to optimal sensitivity and specificity.

3. Results

3.1. Internal consistency

Cronbach's alpha was 0.91 for the total sample, 0.90 for the 3- and 4-year olds, and 0.92 for the 5-year olds, which is above the acceptable level of 0.70 and may be interpreted as 'very good' (Bland & Altman, 1997).

3.2. Construct validity of the LDCDQ-NL

No effects of age ($F(2260) = 0.385$, $p = .68$, $\eta^2 = .003$) were found for the total LDCDQ-NL score. Gender had a significant effect on the total LDCDQ-NL score ($F(1260) = 8.576$, $p = .004$, $\eta^2 = 0.033$), with boys getting lower scores than girls. The interaction between age and gender was not significant ($F(2, 260) = 0.305$, $p = .738$, $\eta^2 = 0.002$). See Table 1 for an overview of mean total LDCDQ-NL scores across group, age, and gender.

Factor analysis (principal components with varimax rotation) resulted in three factors with an eigenvalue larger than one in the whole sample, accounting for 63.1% of the variance (see Table 2). Factor loadings ranged between 0.47 and 0.86 with some items loading on two factors. Factor 1 included 8 items measuring 'Fine motor skills'; Factor 2 included 4 items measuring 'Locomotor skills'; Factor 3 included 3 items measuring 'Ball skills'. The factor structure was rather robust across ages, with one exception: The second factor 'Locomotor skills' became the first factor in the 4- and 5-year old samples with one extra item 'sits upright'; 'Fine motor skills' became the second factor for these age groups.

Total scores of the LDCDQ-NL did not correlate significantly with the total standard scores of the MABC-2-NL Test for the 3-year old children ($r = 0.171$, $p = .106$), but did correlate significantly, but moderately for the 4-year old children ($r = 0.397$, $p < .001$),

Table 1
Mean LDCDQ-NL scores for the TD and at risk group across age and gender.

		TD group		At risk group	
		n	Mean (SD)	*n*	Mean (SD)
Age 3	Female	33	65.1 (9.5)	12	64.0 (10.0)
	Male	37	63.4 (13.0)	8	60.0 (14.2)
	Total	70	64.2 (11.4)	20	62.4 (11.7)
Age 4	Female	34	67.3 (5.9)	14	63.7 (9.4)
	Male	23	66.6 (8.2)	21	57.8 (8.3)
	Total	57	67.0 (6.9)	35	60.2 (9.1)
Age 5	Female	20	68.2 (6.7)	12	66.0 (9.8)
	Male	25	69.1 (6.9)	21	57.9 (8.3)
	Total	45	68.7 (6.7)	33	58.9 (11.0)

Table 2
Factor loadings by item for the total sample (N = 260) Table 2 (continued).

Item	Factor 1 Fine motor skills	Factor 2 Locomotor skills	Factor 3 Ball skills
Throws ball[1]			0.86
Catches ball[1]			0.85
Kicks ball[1]			0.56
Drinks from cup[2]	0.56		
Uses cutlery[2]	0.66		
Holds writing instrument[2]	0.66		
Threads beads[2]	0.75		
Sticks stickers[2]	0.71		
Building games[3]	0.70		
Imitates body positions[3]	0.56		
Sits upright[3]	0.47		
Playground equipment[3]		0.81	
Runs[1]		0.79	
Good coordination[3]		0.65	
Moves from place to place[1]		0.84	
Eigenvalue	6.839	1.371	1.270
% Variance explained	45.5%	9.1%	8.3%

Note: Numbers "1", '2' and '3' beside the items refer to the structure of the original subcategories: 1 = Control During Movement; 2 = Fine Motor; 3 = General Coordination.

and significantly and highly for the 5-year old children ($r = 0.594$, $p < .001$) (see Table 3). It was checked that the correlations between the MABC-2-NL Test and LDCDQ-NL were not explained by a decrease in MABC-2-NL test performance as a function of time. The mean standard scores of the three sub categories (Manual dexterity, Aiming and catching and Balance) of the MABC2-NL among the three age groups did not substantially change from the beginning of the testing to the end: In 3-year olds: *M* 10.73 (*SD* 3.38), *M* 10.64 (*SD* 2.85) and *M* 8.81 (*SD* 2.97); In 4-year olds: *M* 9.25 (*SD* 2.31), *M* 8.71 (*SD* 2.61) and *M* 8.93 (*SD* 3.57); In 5-year olds: *M* 8.72 (*SD* 3.56), *M* 9.20 (*SD* 3.25) and *M* 7.99 (*SD* 3.02)

3.3. Discriminant validity of the LDCDQ-NL

Children in the at-risk group obtained significantly lower mean total scores on the LDCDQ-NL (60.2; SD 10.4) compared to the TD group (66.3; SD 9.1) ($F(1260) = 18.697$, $p < .001$, $\eta^2 = 0.07$). Independent *t*-tests for the difference between the TD and at-risk group for the age groups separately revealed that the groups only differed for the 4- ($t(90) = 4.062$, $p < .001$, $d = 0.84$) and 5-year old children ($t(76) = 4.835$, $p < .001$, $d = 0.106$), but not for the 3-year old children ($t(88) = 0.628$, $p = .532$).

Receiver Operating Curves (ROC) were calculated for all age groups separately and combined. As can be seen from Table 4, Area Under the Curve (AUC) values became larger with increasing age, and when sensitivity was kept at 80%, specificity increased with increasing age.

Table 3
Correlations across age between LDCDQ-NL (factors and total score) and MABC-2-NL Test (subcategories and total standard score).

		MABC2-NL			
		Manual dexterity	Aiming and catching	Balance	Total standard score
LDCDQ-NL Fine motor skills	Age 3	.319**	0.130	0.146	.270*
	Age 4	.392**	0.137	0.196	.360*
	Age 5	.500**	.426**	.610**	.588**
	Total	.392**	0.232	.299**	.414**
LDCDQ-NL Locomotor skills	Age 3	0.171	.233*	0.170	.283**
	Age 4	.383**	0.137	.306**	.375**
	Age 5	.257**	.362**	.491**	.397**
	Total	.285**	.246**	.312**	.372**
LDCDQ-NL Ball skills	Age 3	0.150	.353**	0.062	.221*
	Age 4	0.183	.289**	0.049	.235**
	Age 5	.564**	.436**	.491**	.587**
	Total	.255**	.310**	0.172	.355**
LDCDQ-NL total score	Age 3	0.141	0.118	0.139	0.171
	Age 4	.408**	0.209	0.213	.397**
	Age 5	.487**	.456**	.610**	.594**
	Total	.307**	.235**	.292**	.355**

* $p < 0.01$.
** $p < .001$.

Table 4
ROC data across age groups.

	AUC	*p*-value	Cut-off score	Sensitivity	Specificity
Age 3	0.549	.509	71	80%	30%
Age 4	0.735	< .001	67.5	80%	56.6%
Age 5	0.773	< .001	68	80%	60%
Total group	0.694	< .001	70	80%	40%

4. Discussion

4.1. Main findings

The current study investigated the psychometric properties of the Dutch version of the LDCDQ, and age-related variation in concurrent and discriminant validity. The findings of the Dutch version of the LDCDQ largely supported the psychometric findings from previous studies (Rihtman et al., 2011; Venter et al., 2015; Wilson et al., 2015).

The results regarding internal consistency showed excellent homogeneity indicating that all items related to one construct. All previous studies on the LDCDQ have shown high internal consistency suggesting that each item addresses an aspect of motor coordination in young children (Venter et al., 2015; Wilson et al., 2015). Examination of the way in which the items were organized across factors revealed three factors, a 'Fine motor' factor (8 items) explaining most of the variance (45.5%), and two factors addressing 'Locomotor' and 'Ball skills', respectively. In the original study by Rihtman et al. (2011), experts categorized all 15 items into the three sub-categories of the DCDQ'07, with five items in each category: Control during movement, Fine Motor – Handwriting and General Coordination. However, the factor solution found in the present study was considerably different. The fine motor factor contained the five fine motor items from the original categorization but also two items from the original category 'General coordination'. In the study of Wilson et al. (2015) only two factors were found, the locomotor and ball skill items loaded on one factor and the fine motor items formed the second factor, similar to our first factor. The reason for the different factor structures in the Canadian and Dutch versions is unknown and requires more research to disentangle for example the impact of children's daily environment and the physical activities they typically engage in. However, when we forced a two factor solution in our present study, the same factor structure was found as in the study of Wilson et al. (2015) with one exception: 'sits upright' loaded on the fine motor factor in our study.

Similar to other studies, we found that children's age did not affect their scores on the LDCDQ-NL, suggesting that the parents observed the functional skills of their child in comparison to other children of the same age as addressed in the instructions of the LDCDQ. Gender did, however, play a role in the LDCDQ-NL total score: parents reported boys as less coordinated than girls. Gender was not examined in the original study (Rihtman et al., 2011), but in the study of Wilson et al. (2015) in Canada, separate cut-offs were generated for boys and girls since gender was a significant predictor of the LDCDQ total score. Using the Early Years Movement Skill Checklist (Chambers & Sugden, 2006), parents in the UK and Norway also reported that girls were better coordinated than boys (Moser & Reikerås, 2016). Results from other studies using the M-ABC were equivocal: some studies did report gender differences, as girls in this age range were found to be better at fine motor skills (Chow, Henderson & Barnett, 2001; Livesey, Coleman, & Piek, 2007), other studies, however, did not find gender differences in this age range (Giagazoglou et al., 2011). Gender differences in (observed) motor skills competence might be highly task dependent, even in early childhood. In addition, indications for gender differences in motor skills are possibly in line with stereotypical expectations of the early childhood education system in each country (Moser & Reikerås, 2016).

The LDCDQ-NL had a moderate correlation with the MABC-2-NL Test, which was comparable to the correlation found between these measures in a previous study, that is, 0.29 (Venter et al., 2015). In addition, this correlation was also comparable to the correlations found between the DCDQ'07 and the MABC-2 Test in older children (Civetta & Hillier, 2008; Pannekoek, Rigoli, Piek, Barrett & Schoemaker, 2012; Schoemaker et al., 2006). With further inspection, some interesting age-related patterns were found. The total scores of the LDCDQ-NL did not correlate significantly with the total standard scores of the MABC-2-NL Test for the 3-year old children, but had a significantly moderate to high correlation for the 4-year old children, and a significantly high correlation for the 5-year old children. The non-significant correlation in the 3-year old children may be due to the variability of motor development in this age range. Previous research has suggested that both child-related and environment-related factors can have a confounding role on the results of assessment in this age range (Darrah et al., 2009). Motor development alone in 3-year old children might have a limited potential for prediction of later motor development due to individual dynamics in skill development. In addition, the performance of young children during the assessment of a motor test is very dependent upon performance variables such as motivation, level of attention, fatigue, or boredom. This leads to variable performance across different measurement occasions (Eldred & Darrah, 2010). As a consequence, the performance of 3-year old children does not always reflect their full capability, which may lead to a discrepancy between performance-based results and the parental assessment of their capability. Indeed, these measurements assess motor skills in different ways and in different contexts. That is, while motor tests are carried out by a trained tester at one time point, parents provide complimentary information based on daily observations of their child. It is thus not that surprising if their correlation is low or moderate rather than high. It was checked however that the correlations between the MABC-2-NL Test and LDCDQ-NL in our study were not explained by a decrease in MABC-2-NL test performance as a function of time.

As children grow older, their performance is less susceptible to performance variables, and more in line with their capability. The increase in correlation coefficients between the MABC-2-NL Test and the LDCDQ-NL from 3 to 5 years of age reflected this developmental trend. Likewise, it may also be that parents of younger children were less aware of age-related motor milestones, as their reference frame is still limited (Rihtman et al., 2011). As children get older, they increase their motor repertoire and they interact more with peers. Although parents might become better able to compare the performance of their child in relation to those of peers, questionnaires tap into different kinds of information and in a different context from a motor test. The interpretations of correlations between a motor test and a questionnaire thus need to take into account the complexities associated with assessing young children (Moser & Reikerås, 2016).

Further investigation of the discriminant validity showed that the LDCDQ-NL differentiated between the at-risk group and TD group for 4- and 5-year old children, but not for 3-year old children. This demonstrated that the discriminative power of the LDCDQ-NL was too low in 3-year old children. The discriminative power was best for the 5-year old children. Also, the AUC values showed a similar age trend: The values became larger with increasing age. For an early screening test, it is beneficial to identify all those who are at risk of DCD, which implies that high sensitivity is preferable to higher specificity (Schoemaker, Smits-Engelsman, & Jongmans, 2003; Schoemaker & Wilson, 2015). When sensitivity was kept at 80%, specificity increased with increasing age. Taken together, the present data clearly demonstrated an increase in concurrent and discriminant validity between the LDCDQ-NL and the MABC-2-NL Test as children got older. When also taking into account the low concurrent validity between the LDCDQ-NL and the MABC-2-NL Test for 3-year old children, the present data supported the EACD recommendations on DCD that a diagnosis before the age of 5 is not recommended. However, in case of marked motor impairment before the age of 5, the diagnosis needs to consist of specific steps, including two assessment points with a standardized motor test at least three months apart to control for the effect of spontaneous motor development (Blank et al., 2012).

Nevertheless, although specificity increased with age, even at five years of age specificity was still too low. This implies that if the questionnaire is used as a screening tool, too many false positives will occur and as a consequence unnecessary referrals for further assessment to rule out DCD. This is not very efficient in terms of cost-effectiveness. In older age groups, similar results have been found regarding sensitivity and specificity for most of the questionnaires developed to identify children with DCD, including the DCDQ'07 (Schoemaker & Wilson, 2015). Consequently, the EACD does not recommend the use of questionnaires for population-based screening for DCD (Blank et al., 2012). However, in older age groups sensitivity and specificity did approach the required standards in populations at risk of DCD. Consequently, questionnaires, including the DCDQ'07, can be reliably used in populations at risk of DCD according to the EACD guidelines; they give a reliable picture of the performance of functional motor activities. Whether sensitivity and specificity of the LDCDQ-NL are satisfactory in populations of young children at risk of DCD still needs to be assessed.

Although the concurrent and discriminative validity were not found to be good enough for 3-year old children, the results of an early screening for coordination difficulties in this age group may alert parents to monitor the motor development of their child, as long as parents are notified that motor development may be rather variable in 3-year old children. The use of the LDCDQ-NL to monitor motor development seems particularly useful in the case of concerns about motor development. The results may encourage and empower parents to obtain a formal diagnosis if the child keeps falling behind peers in motor development at a later age.

4.2. Strengths and limitations

The results mirrored those found in related studies in other countries (Venter et al., 2015; Wilson et al., 2015), even though the study population consisted of volunteering parents from a Northern region of the Netherlands and with relatively high educational background, which could have restricted the generalizability of the results to the total population. The internal consistency of the LDCDQ-NL items could only be investigated as an aspect of reliability because no test-retest reliability data were available. It would be worthwhile to include further reliability aspects in a future study. Lastly, we did not control for possible confounding factors such as the child's risk for attention problems, Body Mass Index, parental education, or physical activity which can all exacerbate the risk for DCD.

4.3. Implications for research

It is important to continue investigating the applicability of the LDCDQ and confirm its three factor structure, as well as the possible age- and gender-related differences in a bigger and geographically more representative sample. Furthermore, when motor assessment instruments are developed, possible gender differences need to be considered at all ages. There is a need for a dynamic understanding of age- and gender-based differences in motor development where skillfulness is dependent on characteristics of the motor task, and in a larger perspective, on early childhood practices and cultural expectations. We recommend more longitudinal research to investigate the discriminant validity of the questionnaire by confirming how early (risk) profiles evolve at different ages.

5. Conclusion

In summary, this study provides the first psychometric investigation of a Dutch version of the LDCDQ. There is promising evidence of the LDCDQ-NL's validity and reliability, suggesting that it may be a useful questionnaire for assessment of daily motor skills. The concurrent and discriminative validity for 3-year old children was too limited to recommend use of the LDCDQ-NL as a screening instrument in this age group. Ideally, it needs to be used longitudinally to monitor if children identified with a risk of DCD at age 3 remain behind at age 4 and end up with a DCD diagnosis at age 5. This study adds to previous literature about assessment of DCD and

the relevance of parent-report questionnaires adding to the information obtained with motor tests. For researchers, the LDCDQ-NL has potential to be used in large research studies due to its low cost and ease of completion for parents.

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