Psychometric properties of the French European Little Developmental Coordination Disorder Questionnaire (LDCDQ-FE): a pilot study

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Abstract

Aims. The Little Developmental Coordination Disorder Questionnaire (LDCDQ) is a parental questionnaire designed to identify preschool children at risk of Developmental Coordination Disorder (DCD). This study aimed to translate and cross-culturally adapt the LDCDQ for French European informants (Little Developmental Coordination Disorder Questionnaire – French European [LDCDQ-FE]) and to undertake a pilot examination of its psychometric properties on a French sample. **Methods**. A thorough process of cultural adaptation was completed. The psychometric properties were examined with a sample of 154 French children aged to 5y11m (control=121; clinically referred=33). A sub-group of 34 children was assessed using the MABC-2 to measure convergent validity. **Results**. Principal component analysis demonstrated a four-component structure, accounting for 67.5% of the variance. Internal consistency was acceptable to good (α=0.74-0.89). Significant correlation between the LDCDQ-FE and the MABC-2 total scores showed convergent validity. Discriminant validity was supported by significant score differences between the clinically referred and a matched control sub-group. Using ROC curves, a cut-off of 67 was proposed for a sensitivity of 81.3% and a specificity of 77.8%. **Conclusions**. Results show initial evidence of the psychometric properties of the LDCDQ-FE and are encouraging of its use to identify young preschoolers at risk for DCD. In future studies, the test-retest reliability should be investigated, and study sample sizes expanded.

Keywords

Developmental coordination disorder, screening, psychometric properties, questionnaire, preschool, Little Developmental Coordination Disorder Questionnaire (LDCDQ)

Developmental coordination disorder (DCD) refers to a condition characterized by difficulties in performing age-appropriate motor skills. According to the DSM-5 (American Psychiatric Association, 2013), DCD manifests in motor performance below age-expected levels, with significant impacts upon activities of daily living or academic achievement. Even though DCD is not commonly diagnosed before the age of 5 years (Blank et al., 2019), the onset of symptoms is in the early developmental period (American Psychiatric Association, 2013), and many parents of children who gain a later diagnosis of DCD report having noticed atypicalities in their child's motor abilities before the age of 4 (Missiuna et al., 2007). Increasingly, evidence suggests that DCD has long-term impacts on children's social participation (Chen & Cohn, 2003), mental health (Pratt & Hill, 2011) and physical health (Hendrix et al., 2014). Early identification of children at risk of DCD is therefore crucial to reduce these negative impacts and facilitate effective intervention (Missiuna et al., 2003). The identification and monitoring of younger children who may be at risk of a later DCD diagnosis should start before the age of 5 to prevent longer-term complications through the provision of early developmental support (Camden et al., 2015; Chambers & Sugden, 2002; Wall, 2004).

A central diagnostic criterion for DCD is evidence of motor performance substantially below expected levels, given the person's chronologic age and previous opportunities for skill acquisition (American Psychiatric Association, 2013). For children over the age of 5, the best approach for verifying this criterion is by the use of standardised motor assessments such as the MABC-2 (Henderson et al., 2007) or the Bruininks-Oseretsky Test of Motor Proficiency, 2nd ed (BOT) (Bruininks & Bruininks, 2005). However, due to cost-limitations, full-scale motor testing is not feasible for all children, and questionnaires have been developed to facilitate the screening and detection of children who may be at risk for DCD. Questionnaires contribute to the early detection of children with suspected or probable DCD, are cost-effective (compared to

standardised physical assessment), practical (in terms of time and level of skill of respondent and administrator), useful in clinical settings, provide relatively fast results, and relatively easy analysis (Gabbard & Tamplain, 2021, p.3). Parent-report questionnaires also yield valuable information about motor skills within the child's daily environment (Wilson et al., 2015). In addition to addressing the broader challenges of access to lengthier standardised assessment, questionnaires that support the identification of motor coordination difficulties before the age of 5 have the potential to identify children who would benefit from monitoring and the provision of early intervention support.

Despite these benefits, Gabbard and Tamplain (2021) emphasise the fact that screening questionnaires should not be used without consideration of their potential limitations that are linked to their psychometric properties. Effective appraisal of the clinical utility of screening questionnaires depends on context-specific, careful consideration of validity, reliability, specificity and sensitivity, as well as reported predictive values cut-off scores. However, in many contexts, the lack of valid, reliable and culturally appropriate tools makes it challenging to screen for early markers of DCD. To be clinically useful – even if not intended to be used diagnostically – screening questionnaires require evidence of sound, context-specific psychometric properties.

The Developmental Coordination Disorder Questionnaire (DCDQ) is a parental questionnaire designed to screen for DCD among children between 5 and 15 years (Wilson et al., 2009). It has been translated and cross-culturally adapted in many countries, and displays satisfactory psychometrics properties (Cancer et al., 2020). In light of its wide-spread usefulness, and since it is accepted that markers for DCD are evident in early childhood (American Psychiatric Association, 2013), Parmar et al., (2014) explored the psychometric properties of the DCDQ if used with children under the age of 5. In their study, the usefulness of the DCDQ with 4-6 year

olds was called into question, reinforcing the need for questionnaires exploring motor tasks that are more appropriate for younger children.

Based on the DCDQ, Rihtman et al. (2011) developed The Little Developmental Coordination Disorder Questionnaire (LDCDQ), which was designed to identify 3- and 4-year-old children at risk of DCD with items reflecting more age-appropriate motor tasks. Since its original development in the Hebrew language (Rihtman et al., 2011), the LDCDQ has been adapted and validated for cross-cultural use in multiple countries with numerous validation projects on-going (Rihtman et al., 2015). The different language versions of the LDCDQ show good psychometric properties (Cantell et al., 2019; Fu et al., 2022; Rihtman et al., 2011; Venter et al., 2015; Wilson et al., 2015). For example, internal consistency has been shown to be good to excellent for the total LDCDQ score [Cronbach's alpha coefficients ranging from 0.85 (Rihtman et al., 2011) to 0.95 (Fu et al., 2022)], with fair to excellent test–retest reliability (Intra Class Correlation coefficients (ICC) =0.80-0.98 ; Rihtman et al., 2011). Across versions (e.g. Cantell et al. [2018]; Wilson et al., [2015]; Fu et al., [2022]), both construct and concurrent validity are supported by differences in scores of children who were typically developing and those who were with DCD or at risk for DCD. In some versions of the LDCDQ (Fu et al., 2022), the inter-rater reliability between teachers and parents was poor for the questionnaire total score (ICC=0.47), but the total score of the LDCDQ and the total score of the MABC-2 test have been found to be moderately correlated (r=0.29 [Wilson et al., 2015] to 0.52 [Fu et al., 2022]). However, the factorial structure of the questionnaire has differed across versions, and the sensitivity and the specificity varies according to the cross-cultural adaptation: 86% and 63% in Wilson et al. (2015), 80% and 40% in Cantell et al. (2018), 96% and 68% in Fu et al. (2022).

These findings from the various LDCDQ validation studies demonstrate that it has the potential to be a highly appropriate screening tool in identifying preschoolers at risk for DCD

(Lee & Zwicker, 2021), but reinforce the fact that validated screening tests or questionnaires cannot simply be exported for use in other locations, as an instrument developed in one country may not be psychometrically sound when implemented in a different cultural context. For instance, educational contexts are informed by factors such as socio-political structures, school organisation, and local schoolyard games, all of which should be taken into consideration if ecological validity is to be achieved. Rigorous processes of cross-cultural adaptation of screening and assessment tools should be adhered to, to ensure equivalence between the original and translated versions (Beaton et al., 2000).

In European French speaking countries, no validated tools are available for early screening of young children at risk of a later DCD diagnosis. The availability of a reliable and valid first-step DCD screening questionnaire in French would represent a major advancement in identifying and supporting children. Since the LDCDQ is designed for use with children aged 3 to 4 years, with a range of studies exploring its cultural adaptation, the development of a Little Developmental Coordination Disorder Questionnaire – French European (LDCDQ-FE) version seems timely. Although the original LDCDQ was validated for use with Israeli children between the ages of 3 years and 4 years 11 months (Rihtman et al., 2011), children living in European-French speaking countries attend kindergarten until the age of 6, therefore psychometric testing of the LDCDQ-FE included children aged between 3 years and 5 years 11 months, similar to other validation studies (Cantell et al., 2019; Fu et al., 2022). This age-range extension was agreed after discussion and consultation with the original authors.

This paper aims to describe the translation and cross-cultural adaptation of the LDCDQ into the European French language (LDCDQ-FE), as well report on pilot investigation of the instrument's psychometric properties when used with French preschoolers. We expected the

LDCDQ-FE to present sound psychometric properties and to allow the detection of preschool children who may be at risk of a later diagnosis of DCD.

Methods

Phase 1: Instrument Translation and Cultural Adaptation

The LDCDQ (Rihtman et al., 2011) contains 15 statements describing motor-based tasks that are commonly performed by young children. The instructions emphasise that the parent should compare the child's task performance with that of other children of the same age and sex. Parents are asked to rate the ability of their child to perform each task, on a 5-point Likert scale ranging from *Not at all* to *Strongly - like my child*. Each item is scored from 1 to 5 points, giving a total score of 15 to 75 points, with higher scores reflecting better reported performance. The questionnaire yields three sub-scores (each ranging between 5-25 points): control during movement (CDM), fine motor (FM), and general coordination (GC). Sound psychometric properties of the original LDCDQ have been reported (Rihtman et al., 2011).

Translation and cross-cultural adaptation of the English published version of the LDCDQ into European French was conducted according to international recommendations (Beaton et al., 2000). Translation was performed by the first two authors, who are French and Swiss, yielding a draft version of the LDCDQ-FE. Back-translation was performed by a professional translator. Eight native English speakers were then asked to compare between the two English language versions on a 6-point scale ranging from 0 (*The two versions have exactly the same meaning*) to 5

(*The two versions have different meanings*). The mean score across items was 1.1 (*SD*=1) suggesting satisfactory linguistic equivalence of the initial translation.

At the next stage, a panel of experts (n=6 occupational therapists) were asked to rate the suitability of the translated items to European French speaking children of preschool age. A 5-point scale ranging from 1 (*very appropriate*) to 5 (*not appropriate at all*) was used, with mean expert scores varying from 1 (*SD*=0.3) to 1.6 (*SD*=0.6). During this process, written feedback was also requested from respondents, a process which resulted in additional linguistic adjustments before confirming the final version of the LDCDQ-FE with the original authors. For instance, *cup* (tasse) was replaced with *glass* (verre) as French-speaking children in Europe do not usually use the word *cup*. In addition, a more commonly used term (*crayon)* was identified to replace *writing instrument* (instrument d'écriture), which is not used in everyday language in European French (Jover et al., 2013). This version of the LDCD-FE was then carried forward for psychometric testing as described in Phase 2.

Phase 2: Psychometric Testing

Participants

Participants were parents of preschool children living in France. Children in the *clinically referred group* were recruited via occupational therapists, after being referred due to atypical motor development concerns (n=33). Children with coordination difficulties related to a medical condition or disease (e.g. cerebral palsy, muscular dystrophy) or a suspicion of intellectual impairment were excluded from both groups. Children in the *control group* were recruited via convenience sampling, in liaison with local kindergartens, and did not have any known developmental concerns based on parents and teachers report (n=121). In addition to the larger control group, a *matched control sub-group* (n=33) was formed by matching each child in the

clinically referred group to a child from the control group of the same sex and similar age (± 3 months). One questionnaire from the control group was excluded due to incomplete completion; the final sample was n=154.

For convergent validity and to determine the cut-off score, all parents were asked whether they would agree to bring their children for standardised assessment with the MABC-2 or to provide the results of a recent MABC-2 assessment; a sub-group of n=34 children (n=18 control; n=16 clinically referred) was recruited in this manner and composed the *convergence study group* (Table 1).

- TABLE 1: AT BACK -

Measure

Little Developmental Coordination Disorder Questionnaire – French European (LDCDQ-FE). As per the original LDCDQ, each of the 15 items of the LDCDQ-FE is scored from 1 to 5 points, giving a total score of 15 to 75 points. Lower scores suggest a higher risk for DCD.

Movement Assessment Battery for Children – 2nd edition (MABC-2) (Henderson et al., 2007, French version Marquet-Doléac et al., 2016). The MABC-2 is a standardized assessment of motor performance. It evaluates manual dexterity, ball skills, and static and dynamic balance in children between the ages of 3-16. Children scoring between the 16th and the 5th percentile are considered to be at-risk for DCD and children scoring below the 5th to have DCD if the other DMS-5 criterion are fulfilled. The MABC-2 has demonstrated sound psychometric properties: test-retest reliability (ICC=0.83–0.96) and inter-rater reliability (ICC=0.96-0.99, Griffiths et al., 2018).

Procedure

The study received ethical approval from Aix-Marseille University (approval #32.110213). Parents were informed about the purpose of the study and provided their written consent to participate prior to completing the LDCDQ-FE. Children of the convergence study group were assessed either by their regular occupational therapist or by an experienced research assistant within the 2 months following LDCDQ completion (*M*=25.1 days, *SD*=24.3).

Data Analysis

Data were analyzed using Statistical Package for the Social Sciences, Version 22 (SPSS Statistics; IBM Corp. 2017). The structure of the questionnaire was analyzed on the complete sample using a Principal Component Analysis with Varimax rotation. We opted for this analysis to be able to compare the results to those obtained by Wilson et al. (2015) and Cantell et al. (2018) with the same questionnaire. Internal consistency was assessed using Cronbach's alpha and item-to-total correlations. We used Gliem and Gliem (2003) rule of thumb which considers Cronbach alphas >.9 as Excellent, >.8 as Good, >.7 as Acceptable, >.6 as Questionable and >.5 as Poor. Concerning the Corrected item total correlation, the value should be at least .40 (Gliem & Gliem, 2003). A chi-square test of independence was performed to compare the clinically referred and the matched control sub-group concerning sex and two sample t-tests were used to compare the group's age and MABC-2 standard score.

The effects of the children's age and sex on the LDCDQ-FE scores were explored in the large control group and in the clinically referred group separately. Considering the ordinal level of the LDCDQ response scale, nonparametric tests were used for correlations and comparisons. Correlations between age and LDCDQ-FE scores were analyzed using Spearman's rho correlations. Mann-Whitney U tests were carried out to compare LDCDQ-FE scores between sexes.

Although formal DCD diagnosis does not usually occur prior to the age of 5 such that adherence to formal DCD criteria was not feasible (Blank et al., 2019), children were initially grouped according to the recruitment from clinical settings (clinically referred group) or not (matched control sub-group). The known-group method was used to test the discriminant validity. We compared the clinically referred group and matched control sub-group using Mann-Whitney U tests for the LDCDQ-FE total score and for the LDCDQ-FE subscores obtained from the principal component analysis. Effect sizes were expressed using epsylon squared (ε^2), the rule of thumb for its interpretation is the same as for an adjusted R2 (Vogt, 2005).

The convergent validity was explored in children assessed with the MABC-2 (convergence study group). We estimated the association between the LDCDQ-FE total score and subscores and the MABC-2 standard scores using a Spearman's rho correlation.

To compute preliminary cut-off scores, two new study groups were reconstituted based on MABC-2 outcomes regardless of initial group membership. The *not-at-risk* for DCD group (scores above or at the 16th percentile) was composed of 18 children (15 from the control group; 3 from the clinically referred group). The *at risk* for DCD group (scores below the 16th percentile) was composed of 16 children (3 from the control group; 13 from the clinically referred group). Receiver operating characteristic (ROC) curves were used to determine preliminary optimum cut-off values, using the MABC-2 score as the state variable (*at-risk* and *not-at-risk* groups). The point on the ROC curve that allowed for a sensitivity of around 80% was selected as the cut-off (Schoemaker & Wilson, 2015). Sensitivity and specificity values, as well positive and negative predictive values according to the cut-off, were calculated. For all analyses, the statistical significance level was set at 0.05.

Results

Sample characteristics (Table1). The participants ranged in age from 36 to 71 months in the large control group and from 40 to 71 months in the clinically referred group/matched control sub-group. As expected, the age and the sex distribution did not differ between the clinically referred group and the matched control sub-group. The MABC-2 standard scores were lower in the clinically referred group than in the large control ($t(32) = 4.45$, $p < 0.001$) and in the matched control sub-group ($t(26) = -3.64$, $p = 0.001$).

Principal Components Analysis and internal consistency. The Principal Components Analysis with Varimax rotation resulted in four factors (components) with an eigenvalue higher than one (Table 2). The factors accounted for 67,5% of the variance. The factor loadings were between 0.46 and 0.82 with one item loading on two factors. The four factors of the LDCD-FE were labelled *Daily activities* (4 items), *Fine motor activities and games* (5 items), *Ball skills* (3 items) and *Posture and global coordination* (3 items).

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Internal consistency of the LDCDQ-FE was acceptable to good as the Cronbach's alpha coefficient was 0.89 for the total score, 0.82 for F1, 0.80 for F2, 0.74 for F3 and 0.74 for F4. Corrected item-total correlations demonstrated a moderate contribution of each item to the overall questionnaire (range=0.48-0.69), which was slightly increased when considering each component separately (range=0.48-0.72). Cronbach's alpha coefficient for the total score remained good if items were deleted for the total score (0.88-0.89), and it was poor to good for the components considered separately (0.58-0.83, Table 3).

- TABLE 3: AT BACK -

As the instructions of the LDCDQ-FE guide parents to consider their child's performance in relation to other children of the same age and sex, we expected the LDCDQ-FE scores (Total

score, F1, F2, F3 and F4) to not depend on age or sex. As predicted, none of the correlations between age and LDCDQ-FE scores were significant (Total score: control group $r = 0.08$, $p > 0.4$; clinically referred group $r = 0.06$, $p > 0.7$). Likewise, no significant difference between girls and boys we found across the LDCDQ-FE scores.

Discriminant validity. The known-group method was used. LDCDQ-FE total score and subscores were computed across clinically referred group and matched control sub-group (Table 4). The difference between the clinically referred group and matched control sub-group was tested with Mann-Whitney U tests and was significant for all scores. The children who had been referred to occupational therapy due to motor difficulties had lower scores than the children of the matched control sub-group for the total score and each subscore of the LDCDQ-FE. The magnitude of the effect size was small for F3 Ball skills, medium for F1 Daily activities and large for F2 Fine motor activities and games and F4 Posture and general coordination.

- TABLE 4: AT BACK -

Convergent validity. The LDCDQ-FE total score was correlated to the MABC-2 total standard score (Table 5). Correlations between the LDCDQ-FE and the MABC-2 subscores were also considered. F1 and F2 were the only factors correlated to the MABC-2 total score and were also the factors which correlated the most with the MABC-2 subscales. The F1 *Daily activities* was correlated to the *Manual dexterity* and the *Balance* subscales of the MABC-2. The F2 *Fine motor activities and games* was correlated to each MABC-2 subscore (*Manual dexterity*, *Aiming and catching*, *Blance*). On the contrary, F3 and F4 were correlated to only one subscale of the MABC-2. Consistently, F3 *Ball skills* was correlated to *Aiming and catching*, but F4 *Posture and general coordination* was correlated to the *Manual dexterity* subscale of the MABC-2.

- TABLE 5: AT BACK -

Cut-off scores, sensitivity and specificity. The optimal cut-off in the sample was explored through the ROC method. The ROC curve is presented Figure 1, the x-axis represents the false positive rate (1-specificity) and the y-axis the true positive rate (sensitivity). The estimated area under the ROC curve was 0.82 (CI_{95}=0.66-0.97) and significantly different than 0.50 (p=0.002). Considering the LDCD-FE total score, a cut-off of ≤67 led to an associated sensitivity of 0.81, a specificity of 0.78, a predictive positive value of 0.76 and a predictive negative value of 0.82.

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Discussion

The aim of the present study was to cross-culturally adapt and conduct a preliminary assessment of the psychometric properties of the LDCDQ for use with 3- to 5-year-old children living in French-speaking European countries. The translation of the questionnaire and its cultural adaptation were conducted and resulted in a pilot version, which was then psychometrically tested with a French sample. Results provided sound initial evidence of the internal consistency and the validity of the LDCDQ-FE.

The finding of very good internal consistency (substantially above the level of .70; Bland, Altman,1997) implies that the LDCDQ items were homogeneous in relation to the construct of motor coordination and warranted included in the French European version of the questionnaire. This finding, which aligns with that of other validated versions of the LDCDQ (Cantell et al., 2019; Fu et al., 2022; Wilson et al., 2015), supports the assumption of a central construct related to early motor development and reinforces the importance of understanding the manner in which young children perform day to day motor tasks as an indicator of their early motor development.

Examination of the structural organization of the LDCDQ-FE revealed four components specific to this version of the questionnaire (*Daily Activities*: items related to eating, moving from place to place; use of playground equipment; *Fine Motor Activities and Games*: puzzles, building a block tower, sticking stickers; Simon Says; *Ball Skills*: all ball-related items; *Posture and Global Coordination:* sitting, running). This factorial structure explained a large part of the variance, however, differs from the factor structures of other LDCDQ versions. For instance, the original study comprised 3 subscales relying on experts' categorization of the items between three categories and in an attempt to propose alignment with the general structure of the DCDQ (Wilson et al., 2009): control during movement, fine motor, general coordination (Rihtman et al., 2011). Wilson et al. (2015) and Cantell et al. (2019) both used principal component analysis but obtained 2 factors (gross motor and fine motor) and 3 factors (fine motor skills, locomotor skills, ball skills), respectively. The structure that is emerging in different versions may be describing differing associations between items made by the parents within specific cultural contexts as well as reflect culturally-specific differences in opportunities for motor development. For example, the Simon Says game (or equivalent) was associated with fine motor skills in France and the Netherlands (Cantell et al., 2019), but with gross motor skills in Canada (Wilson et al., 2015) and general coordination in Israel (Rihtman et al., 2011). More research is needed to identify how cultural differences potentially shape parental assessment, and how the parental assessment differs from the traditionally accepted views of professionals in relation to components of motor function.

The LDCDQ-FE scores did not depend on sex or age, which is in line with the questionnaire instruction to respondents to consider the child as compared to other children of the same sex and age, and an important aspect of verifying construct validity of the instrument. Concerning sex, this result aligns with findings from other versions of the questionnaire (Rihtman et al., 2011) and

that of the French European adaptation of the DCDQ, designed for 5- to 15- year-old children (Ray-Kaeser et al., 2019). However, some adaptations of the LDCDQ appear to elicit lower scores from boys than from girls despite this instruction (Cantell et al., 2019; Fu et al., 2022; Wilson et al., 2015). Again, the cultural context may explain this divergence. Parental expectation might be relatively comparable for boys and girls in France, whereas they may be higher for boys in Canada, Netherland, or Taiwan, leading to lower scores in this group. Alternatively, culturally-based, sex-related expectations for different motor activities may underlie these different findings. These comparative findings suggest the need for further exploration of the underlying reasons that may explain these differences (see Rihtman et al., 2015). Concerning the age, the present adaptation focuses on a group of 3-, 4- and 5-year-old children, whereas the original LDCDQ was designed to assess 3- and 4-year-olds. The correlation between age and LDCD-FE score was very low, suggesting that the inclusion of older children did not affect the parent's responses. The inclusion of 5-year-old children was supported by other studies (Cantell et al., 2019; Fu et al., 2022) and the instructions for the questionnaire are compliant as they require parents to rate their children 'in relation to other children of the same age' (Wilson et al., 2009; Wilson et al., 2000). Except in Fu et al. (2022)'s study which showed a decrease of the LDCDQ-C score with age, no age effect has ever been obtained with the LDCDQ between 3 years and the end of the 4th year (Rihtman et al., 2011; Wilson et al., 2015) or between 3 years and the end of the 5th year (Cantell et al., 2019). Thus, further validation should continue to include children up to the end of their 5th year, because children attend kindergarten across these age ranges in many European French speaking countries. As the DCD-FE comprises children between 5 and 15 years (Ray-Kaeser et al., 2019), the addition of the LDCDQ-FE means that there are now two questionnaires available to support screening of European French speaking 5-year-old children. We recommend choosing the questionnaire according to the child

scholarship: LDCDQ-FE for children attending kindergarten and DCDQ-FE for children already going to school.

To test the construct validity of the LDCDQ-FE, the scores of children in the clinically referred group and a matched control sub-group were compared. The significant difference suggests that the LDCDQ-FE captures parental perception of their child's early motor difficulties (Missiuana et al., 2007), in each domain explored: daily activities, fine motor activities and games, ball skills, posture and general coordination. Moreover, the correlation between the MABC-2 and the LDCDQ-FE attested to a satisfactory convergent validity of the questionnaire: it was slightly higher than those obtained by Fu et al. (2022) or Cantell et al. (2019) on children aged from 3 to 5 years (0.52 and 0.36 respectively), and also higher than those obtained by Wilson et al. (2015) and Venter et al. (2015) on children aged from 3 to 4 years (0.30 and 0.29). The first two factors of the questionnaire (F1 Daily activities and F2 Fine motor activities and games), in particular, strongly correlated with the MABC-2 physical assessment and need careful consideration in case of suspected DCD. These two factors may be particularly good examples of the day-to-day effect of motor coordination difficulties in children before 6 years (e.g. Wang et al., 2009). The lack of correlation between F3 Ball skills and F4 Posture and general coordination and the MABC-2 Total score potentially rely on the fact that these components count less items (3) and a reduced variability of the scores. Each of these components however correlated with one subscore of the MABC-2. On the whole, the correlation between the MABC-2 and the LDCDQ-FE confirms the usefulness of the questionnaire to screen for children below six years at-risk for DCD as a reflection of diagnostic criterion B (APA, 2013), although it is not intended to replace a formal motor assessment (which addresses diagnostic criterion A [APA, 2013]). The questionnaire constitutes a means to *encourage parents to monitor their child's motor*

development and obtain a standardized motor assessment if he/she keeps falling behind peers at a later age (Cantell et al., 2019, p.34), and the addition of a validated European French version is a welcome, culturally-specific addition to support quality clinical practice.

The cut-off scores of the LDCDQ-FE were calculated using ROC analysis, setting the standard of sensitivity to 80%, as recommended by Schoemaker and Wilson (2015). These authors assumed that sensitivity should be higher than specificity when a screening instrument is used to detect DCD, where early diagnosis is beneficial, diagnosis is easy to confirm using a noninvasive motor test, and a false positive has few psychological consequences (Schoemaker and Wilson, 2015; Schoemaker et al., 2003). A cut-off score of 67 was the best way of distinguishing children *at-risk* from children *not-at-risk* for DCD. In other words, children scoring at or below this cut-off should be considered for further motor assessment, as they may be considered as being at risk for having DCD. This value is comparable to the one proposed by Wilson et al. (2015) (67-68 - children aged 3 and 4 years) yet lower than the one suggested by Cantell et al. (2019) (70 - children aged 3, 4 and 5 years). The findings reported here reinforce the necessity to ensure psychometric testing of tools when adapted for use in other cultures (Rihtman et al., 2013). The questionnaire's sensitivity (81%) and specificity (78%) attested its ability to correctly classify a child as being at-risk for DCD (true positive) or not-at-risk for DCD (true negative). Likewise, the questionnaire can help to determine if a formal motor assessment or motor support may be needed.

The present study has limitations. First, it is a pilot study, and the limited sample size mitigates the strength and generalizability of its results. Second, the participants come from only one country and the educational level of the mother was not measured as a potential confounding variable. Further studies should be conducted before using the questionnaire in other French - speaking European countries. Finally, due to the limited number of participants who performed

the MABC-2, it was not possible to calculate the cut-off score by age category. Therefore, future research investigating the LDCDQ-FE should aim to establish age-band specific cut-off scores. Future research should also aim to estimate the test-retest reliability.

Conclusions

In conclusion, the results of the current study suggest that the LDCDQ-FE has preliminary evidence of satisfactory psychometric qualities as a screening instrument (internal consistency, discriminant and convergent validity, sensitivity and specificity). As the LDCDQ-FE focuses on functional skills in a range of contexts, it has noteworthy potential to detect those preschool children who would benefit from early support[1].

[1] The questionnaire is available through request to the authors.

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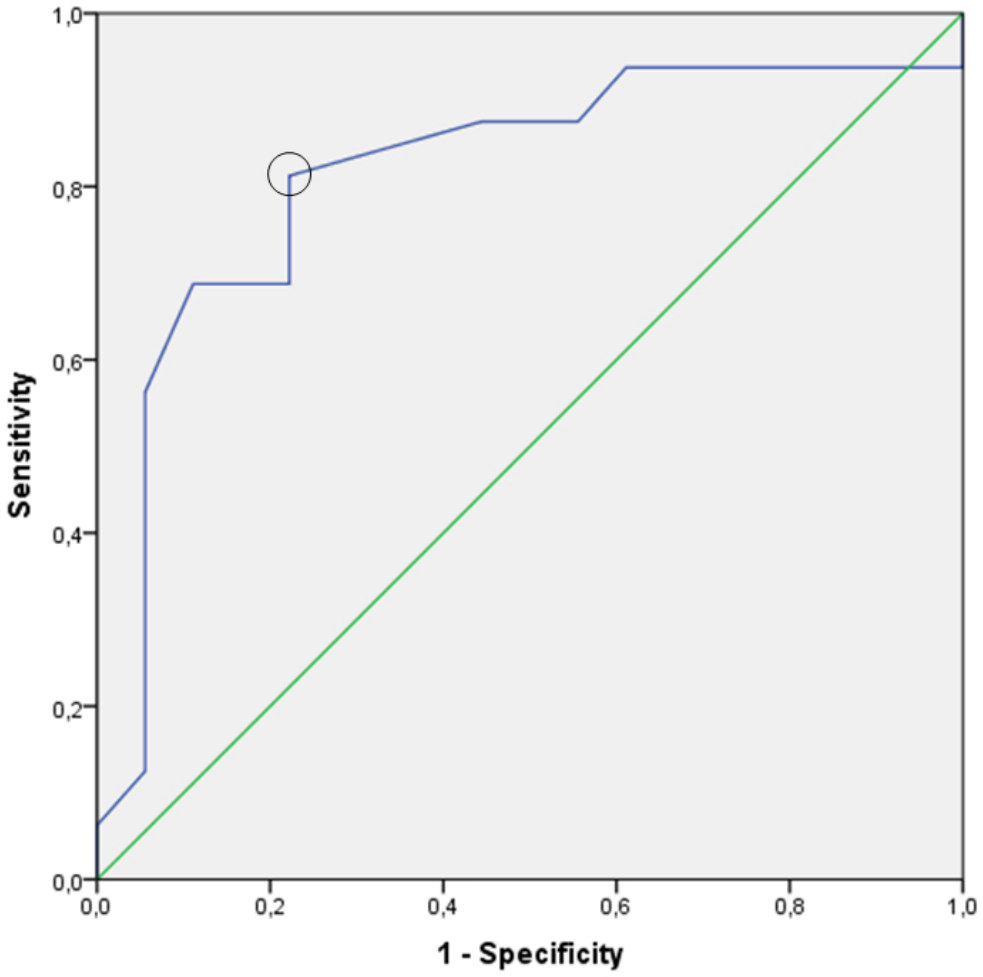

Figure 1: LDCDQ-FE Receiver Operating Characteristic (ROC) curve (diagonal segments are produced by ties) for a cut off ≤67. The cut off point is represented by the circle.

312x310mm (57 x 57 DPI)

Table 1. Group characteristics: number of children and age according to sex, and MABC-2 standard score

		Clinically referred group			Matched control sub-group			Control Group			Convergence study Group		
		n	mean	(SD)	n	mean	(SD)	n	mean	(SD)	n	mean	(SD)
Age (month)	F	11	54.2	(9.9)	11	54.2	(10.1)	48	50.6	(9.0)	14	51.3	(9.3)
	M	22	57.1	(8.4)	22	57	(8.4)	73	52.2	(9.6)	20	53.9	(9.7)
	T	33	56.2	(8.9)	33	56.1	(9.0)	121	51.5	(9.4)	34	52.8	(9.5)
MABC-2 (SS)		16	4.19	(3.1)	12	9.1	(4.0)	18	9.8	(3.9)	34	7.1	(4.5)

Note : F = Female, M = Male, T = Total, SS = standard score, n = number, SD = standard deviation

Table 2. Principal Components Analysis and factor loading by items (n=154)

	F1 Daily activities	F2 Fine motor activities and games	F3 Ball skills	F4 Posture and general coordination
Eigenvalue	6.47	1.42	1.16	1.07
Variance explained (%)	43.1	9.5	7.7	7.1
I13 Playground equipment (GC)	0.82	0.22	0.15	0.09
I6 Drinks from cup (FM)	0.79	0.15	0.17	0.20
I5 Moves from place to place (CDM)	0.76	0.22	0.33	0.03
I7 Uses cutlery (FM)	0.65	0.31	-0.01	0.14
I10 Sticks stickers (FM)	0.45	0.74	0.15	0.02
I9 Threads beads (FM)	0.18	0.75	0.09	0.22
I8 Holds writing instrument (FM)	0.34	0.70	0.20	0.08
I12 Imitates body positions (GC)	0.13	0.59	0.43	0.20
I11 Building games (GC)	0.08	0.53	0.28	0.29
I1 Throws ball (CDM)	0.14	0.16	0.78	0.10
I2 Catches ball (CDM)	0.18	0.13	0.76	0.22
I3 Kicks ball (CDM)	0.17	0.32	0.76	0.01
I15 Sits upright (GC)	0.02	0.30	0.13	0.80
I14 Good coordination (GC)	0.41	0.13	0.13	0.76
I4 Runs (CDM)	0.58	0.09	0.43	0.46

Note: I = Item; Letters in parentheses refer to the original subcategories in Rihtman et al. (2011): CDM control during movement; FM fine motor; GC general coordination.

Table 3. Internal consistency of the LDCDQ-FE items (n=154)

LDCDQ-FE items	Corrected item-total correlation (total score)	Alpha if item deleted (total score)		Corrected item-total correlation (F1, F2, F3, F4)	Alpha if item deleted / component (F1, F2, F3, F4)
I5 Moves from place to place	0.635	0.883	F1	0.677	0.763
I6 Drinks from cup	0.613	0.883	F1	0.697	0.753
I7 Uses cutlery	0.505	0.886	F1	0.545	0.834
I13 Playground equipment	0.605	0.885	F1	0.722	0.760
I8 Holds writing instrument	0.638	0.880	F2	0.633	0.751
I9 Threads beads	0.571	0.886	F2	0.629	0.771
I10 Sticks stickers	0.673	0.880	F2	0.717	0.738
I11 Building games	0.509	0.886	F2	0.484	0.795
I12 Imitates body positions	0.619	0.882	F2	0.583	0.772
I1 Throws ball	0.519	0.886	F3	0.581	0.701
I2 Catches ball	0.554	0.886	F3	0.623	0.662
I3 Kicks ball	0.571	0.883	F3	0.626	0.589
I4 Runs	0.690	0.879	F4	0.568	0.675
I14 Good coordination	0.592	0.883	F4	0.630	0.581
I15 Sits upright	0.480	0.890	F4	0.535	0.711

Note: I = Item, F1 Daily activities, F2 Fine motor activities and games, F3 Ball skills, F4 Posture and general coordination

Table 4. LDCDQ-FE total score and subscores in the clinically referred (n=33) and matched control (n=33) sub-groups

	Clinically referred Group mean (SD)	Matched control Sub-Group mean (SD)	Mann-Whitney U test		
Total	59 (9.4)	69.5 (5.3)	U=161	$p<0.001$	$\varepsilon^2 = 0.373$
F1 Daily activities	17.8 (3.1)	19.4 (1.4)	U=341	$p=0.003$	$\varepsilon^2 = 0.145$
F2 Fine motor activities & games	18.6 (4)	23.3 (1.9)	U=153	$p<0.001$	$\varepsilon^2 = 0.394$
F3 Ball skills	11.9 (2.7)	13.6 (1.5)	U=352	$p=0.012$	$\varepsilon^2 = 0.098$
F4 Posture & general coordination	10.6 (2.9)	13.2 (2.18)	U=250	$p<0.001$	$\varepsilon^2 = 0.225$

Note: SD: standard deviation

Table 5. Correlation between LDCDQ-FE total score and subscores and the MABC-2 standard scores (n=34)

	MABC-2			
LDCDQ-FE	Total	Manual dexterity	Aiming and catching	Balance
Total score	0.575***	0.647***	0.315	0.426*
F1 Daily activities	0.485**	0.559***	0.166	0.405*
F2 Fine motor activities and games	0.541***	0.565***	0.351*	0.357*
F3 Ball skills	0.313	0.245	0.576***	0.121
F4 Posture and general coordination	0.319	0.489**	-0.037	0.252

Note: Spearman rho correlations. * p<0.05, ** p<0.01, *** p<0.001