Title: Cross-cultural validation of the Brazilian Little Developmental Coordination Disorder Questionnaire (LDCDQ-BR) for preschool children.

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- Barbara L. C. Moraes was responsible conceptualizing and writing the research project, for data collection, data interpretation, manuscript writing and revision.
- Vanessa Maziero Barbosa worked on data analysis and interpretation, preparation of the manuscript and English revision
- Ana Amélia Cardoso worked on the transcultural translation of LDCDQ to Brazilian Portuguese, conceptualization of the research project; follow up of data collection, data interpretation, manuscript writing and revision.
- Tanya Rihtman, the original author of the LDCDQ, supported the translation process, collaborated in conceptualizing the research project, data interpretation, preparation of the manuscript and English revision
- Lívia de Castro Magalhães, the project's administrator, was responsible for the transcultural translation of the LDCDQ to Brazilian Portuguese, conceptualization of the project, definition of methods and resources, data collection, data analysis and interpretation, manuscript writing and revision.

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ABSTRACT

Introduction: Motor difficulties associated with Developmental Coordination Disorder (DCD) are frequently apparent before the accepted diagnostic age of 5. Tools to support identification of DCD markers would allow provision of early intervention to reduce negative sequelae. *Objective:* Establish psychometric properties and define preliminary cut-off scores for the Brazilian Little Developmental Coordination Disorder Questionnaire - Brazil (LDCDQ-BR). *Methods and procedures:* Parents of 3- and 4-year-old children (n=312; 154 girls) from Belo Horizonte/MG, Brazil, completed the LDCDQ-BR, the Brazil Economic Classification Criterion and a demographic questionnaire. One sub-set of children (n=119) was assessed with the Movement Assessment Battery for Children–2nd Edition; another sub-set (n=77) completed the LDCDQ-BR a second time. *Results:* Rasch analysis indicated good item functioning with only one erratic item, suggesting unidimensionality. Item calibration reliability was excellent (0.97), children's measures reliability was low (0.72), but implying separation of 2.46 motor ability levels. Significant, low correlations were found between the LDCDQ-BR and MABC-2 (r=0.30, p<0.01). Test-retest reliability was 0.77 (total score) and 0.44-0.78 (individual items). ROC curve analysis revealed sensitivity of 68% at a cut-off score of 64. *Conclusion:* The LDCDQ-BR shows promising psychometric properties to support early identification of DCD.

Keywords: Developmental Coordination Disorder; Screening; Little Developmental Coordination Disorder Questionnaire; Validity; Reliability; Early Identification.

HIGHLIGHTS

- Rasch analysis was used to examine the measurement properties of the LDCDQ-BR.
- Items were easy, but fit the Rasch model, suggesting unidimensionality.
- Total score was valid, but subcategory scores were not.
- The items discriminate two levels of motor ability.
- Total score ≤64 suggests possible DCD in 3 and 4 years old Brazilian children.

WHAT THIS PAPER ADDS?

This study adds information on the psychometric properties and cut-off point for the Brazilian Little Developmental Coordination Disorder Questionnaire (LDCDQ-BR), a much-needed screening tool to identify possible motor coordination problems in 3- and 4-year-old children. This is the first study to use the Rasch model to explore the strengths and weaknesses of the questionnaire. The items fit the model but are easy for typically developing children, discriminating just two motor ability levels, which is the minimum required for screening purposes. Validity of the total score was confirmed, but not of sub-scores. Children from private schools that participate in extra-class motor activities obtained higher scores in the LDCDQ-BR, supporting the idea that different experiences affect early motor development. Low sensibility illustrates how difficult it is to identify mild motor problems in young children.

1. INTRODUCTION

The first years of life are characterized by intense processes of learning and motor development. In this period, young children acquire complex skills that underpin future task performance, including the ability to coordinate movements efficiently. However, some very young children present uncoordinated movements and motor difficulties that differentiate them from others in the same age group. These difficulties can indicate Developmental Coordination Disorder (DCD) (Blank et al., 2019).

According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM–5), a diagnosis of DCD is made when the individual's motor skills are substantially below expectations for chronological age, despite opportunities for skill acquisition and use. These motor deficits begin in early childhood, are not explained by any other disorders and significantly interfere with activities of daily living (APA, 2013). DCD is more frequently diagnosed in boys, with a commonly reported prevalence of 5-6% of school-age children (APA, 2013). The prevalence in Brazil ranges from 4.3-19.9% in children aged 4-12 years (Beltrame, Capistrano, Alexandre, Lisboa, & Andrade, 2017; Cardoso, Magalhães, & Rezende, 2014; Teixeira, Gimenez, Oliveira, & Dantas, 2010), with this variation attributed to the type of motor developmental test used and adherence to DSM-5 diagnostic criteria (Smits-Engelsman, Schoemaker, Delabastita, Hoskens, & Geuze, 2015).

DCD is commonly associated with other developmental disorders and characterized by heterogeneity of presentation (Blank et al., 2019). Yet, regardless of presentation, children with DCD may miss opportunities to participate in typical motor activities of childhood (Pulzi & Rodrigues, 2015) which can compromise their sense of competence and generate secondary emotional and social challenges (Poulsen, Johnson, & Ziviani, 2011). Individuals with DCD are at higher risk of reduced quality of life, including difficulties in psychological, social, school, and work domains (Blank et al., 2019). These negative impacts persist into adolescence and adulthood, causing emotional difficulties, mental health challenges, and social isolation (Engel-Yeger, 2020), directly influencing participation in daily activities (Harrowell, Hollén, Lingam, & Emond, 2018).

Due to variability of normal early motor development, the diagnosis of DCD is not recommended before age 5, except in cases of severe motor impairment (Blank et al., 2019). However, markers for a later diagnosis of DCD are frequently evident before this age (Rihtman, Wilson, & Parush, 2011). Early identification of younger children at risk for a DCD diagnosis allows preventive guidance and intervention, which may help to support motor skill development and encourage more effective participation across contexts, which can potentially reduce the social, behavioral, and psychological consequences associated with DCD (Rihtman et al., 2011).

For early detection to be possible, culturally appropriate, psychometrically sensitive instruments are needed. The use of questionnaires to detect motor difficulties in low and middle-income countries is particularly useful given their low cost and simple administration, without the costs associated with specialized professional test administration (Giofrè, Cornoldi, & Schoemaker, 2014; Henderson, Sugden, & Barnett, 2007; Linde et al., 2016). The Developmental Coordination Disorder Questionnaire (DCDQ'07) is an example of such a screening tool which has been widely investigated to support the diagnosis of DCD (Blank et al., 2019). This simple, 15-item instrument has been translated into multiple languages for use across numerous cultures, and has a Brazilian version (DCDQ'07-Brasil [DCDQ-BR]) (Prado, Magalhaes, & Wilson, 2009) which is widely used clinically and in research in Brazil (Agostini, Magalhães, & Campos, 2014; Franca, Cardoso, & Araújo, 2017; Sarraff, Martinez, & Santos, 2018). However, while the DCDQ’07 is particularly useful for obtaining information on functional performance and for engaging parents in the assessment process (Blank et al., 2019), it is not suited for use with children under age 5.

The Little Developmental Coordination Disorder Questionnaire (LDCDQ) was originally developed in the Hebrew language (Rihtman et al., 2011) to identify markers for DCD in children aged 3 and 4 years. Similar to the DCDQ'07, the LDCDQ comprises 15 items where parents report on their perceptions of the child's performance in functional everyday home and school activities. As part of an international research collaboration, an English language translation of the original LDCDQ (Rihtman et al., 2011) has been cross-culturally adapted for use in numerous countries. To date, published LDCDQ validation projects (Cantell, Houwen, & Schoemaker, 2018; Chung et al., [in press]; Venter, Pienaar, & Coetzee, 2015; Wilson et al., 2015) have led to context-specific amendments to different LDCDQ versions. These include adjustment of item details (when original item tasks would not be familiar to local contexts), extension of the age range to include 5-year-old children (in cultures where children attend kindergarten from ages 3-5) and the suggestion of alternative sub-scores (when factor analyses suggested different questionnaire structures). These studies have all demonstrated adequate psychometric properties of the various versions of the LDCDQ.

This paper describes the translation and cultural adaptation of the Brazilian Little Developmental Coordination Disorder Question (LDCDQ-BR), reports on reliability and validity evidence using both Rasch analysis and Classical Test Theory (CTT), and defines preliminary cut-off scores for the identification of 3- and 4-year old Brazilian children at risk of a future DCD diagnosis.

2. METHOD

2.1 Participants

Based on an estimated 5% prevalence of DCD (APA, 2013), combined with the recommended minimum of 10 scores per score category for stable Rasch analysis (Linacre, 2002), a minimum total sample size of 200 children was estimated. To ensure a robust sample that would allow, if necessary, separate calibration of items by age, a minimum sample of 150 children per age group was sought. A convenience sample of 312 children (age 3: n=154[n=75 girls]; age 4: n=158[n=79 boys]) was recruited from public (n=155) and private schools (n=157) in Belo Horizonte, Brazil. Private school children often have more access to paid extra-class motor activities, such as dance and sports. We aimed to recruit equal numbers of age- and gender-matched children from public and private schools.

Inclusion criteria stipulated that children were aged 3 to 4 years 11 months whose parents had sufficient reading skills to complete the questionnaires. Children were excluded if the LDCDQ-BR was not fully complete, parents reported neuromuscular diseases, cerebral palsy, autism, cognitive delay, hearing and/or visual impairments, serious orthopedic problems (e.g. lower limb fracture), prolonged illness in the three months preceding assessment, or had previously received physical or occupational therapy.

Participants were predominantly children from middle-class families but with all economic levels represented: level A=16.8%; level B=51.3%; level C=28.4% and level D-E=3.5%. Parental educational level varied: incomplete elementary school=1.9%; elementary school=3.5%; middle school=8.7%; high school education=34.9%; higher (university) education=45.2%; 5.8% were missing. Children's characteristics are shown in Table 1. The 3- and 4-year-old groups did not differ in terms of gender, type of school and participation in extra-class physical activities. Although more children from private schools participated in physical activities, there was no age-related difference on MABC-2 scores (U=1653.00; ES=-0.051).

Table 1: Participants characteristics according to age

Variable	3 years (n=154)	4 years (n=158)	P value
Age (months)			
(M±SD)	41.95(±3.32)	53.85(±3.62)	-
(median)	42.00	54.00	
Gender *n (%)*			
Male	79(51.3%)	79(50.0%)	0.819[c]
Female	75(48.7%)	79(50.0%)	
School *n (%)*			
Public	74(48.1%)	81(51.3%)	0.570 [c]
Private	80(51.9%)	77(48.7%)	
Physical activity *n (%)*[a]	46(29.9%)	53(33.5%)	0.486 [c]
Public schools (n=17)	8(8.08%)	9(9.09%)	**0.001**[c]
Private schools (n=82)	39(39.39%)	43(43.43%)	
MABC-2 (percentile)[b] *Median/ M±SD*	25.00/35.11(±26.1)	37.00/37.31(±26.71)	0.633[m]

[c]Chi Square; [m]Mann Whitney; p values in **bold** indicate significant difference; [a]Values for children who perform physical activities; [b]Children assessed with MABC-2 (n=119 [52 aged 3; 67 aged 4]).

2.2 Measures

Brazilian Little Developmental Coordination Disorder Questionnaire - LDCDQ-BR (Rihtman et al., 2011): a 15-item questionnaire to screen for early markers of DCD amongst children aged 3 and 4 years. Parents/caregivers are asked to rank the child's performance of daily activities as compared to other children of the same age and gender. A Likert scale of 1 (Not at all like my child) to 5 (Extremely like my child) is used, generating a maximum total score of 75 (higher scores suggest better performance). Three sub-scores based on theoretical considerations are calculated (each comprising 5 questions; maximum subscore of 25): control during movement (CDM), fine motor skills (FM) and general coordination (GC). Raw total and sub-scores were used for all analyses.

The Movement Assessment Battery for Children 2nd Edition - MABC-2 (Henderson et al., 2007): a standardized test of motor function, commonly used in the identification and diagnosis of DCD among children aged 3-16 years. The MABC-2 comprises eight tasks, in three motor areas: aiming and catching, manual dexterity, and balance. Performance on each task is scored considering time taken or number of errors. Total raw scores are converted into standardized score and percentiles: performance ≤5th percentile is indicative of motor deficit, between 6th-15th percentile is indicative of motor deficit risk, and scores ≥16th percentile are considered typical. In the current study, the 3-6 year age band was used; scores <16th percentile were used to identify children at risk of or with motor deficit. The MABC-2 has been translated into Brazilian Portuguese with evidence of sound psychometric properties: face validity (98% agreement among health professionals), satisfactory internal consistency (Cronbach's alpha 0.52-0.77), adequate interrater (intraclass correlation coefficient [ICC]=0.86 - 0.99) and test-retest (r=0.74; p<0.0001) reliability (Valentini et al., 2012).

Economic Classification Criterion Brazil - ECCB (Associação Brasileira de Empresas de Pesquisa, 2016): based on the ownership of specific items (e.g., number of bathrooms, refrigerators, microwaves or cars) and the education level of the family head, the ECCB categorizes the Brazilian population into eight classes - A1, A2, B1, B2, C1, C2, D, and E - representing different economic levels, in which A is the highest and E the lowest economic level.

Demographic questionnaire: developed for the current study to gather sociodemographic and clinical data. This questionnaire included questions about the child's participation in extra-class motor activities (e.g., sports or dance classes). These are common activities in Brazil, especially among higher-income children who attend private schools, which could influence the parents' perception about the child's motor performance, as well as constitute a potential confounding factor.

2.3 Procedure

The LDCDQ was translated into Brazilian Portuguese in five stages, according to guidelines for cross-cultural adaptation of health related questionnaires namely: translation, synthesis, back translation, expert review and pretest (Beaton, Bombardier, Guillemin, & Ferraz, 2000). To ensure less regionalized translation, researchers from three Brazilian regions collaborated in this process. During the expert review stage, items 9 (thread beads) and 10 (sticking stickers) were identified as culturally unsuitable. Item 9 was therefore adapted to 'posting coins' and item 10 was adjusted to include gluing a precut figure on a specific spot. In the pretest, items 2 (…catches a large ball with both hands… from a distance of 1.5m [ages 3] or 2m [ages 4]) and 8 (…holds a pencil or crayon…to scribble with it [ages 3] or copy simple lines and shapes [age 4]), that indicated distinct skills for 3 and 4 years old, were considered confusing by parents. Therefore, the questionnaire was split into two comparable forms for ages 3 and 4 respectively.

After obtaining ethical approval (Federal University of Minas Gerais [ETIC 12547019.4.0000.5149]), 15 schools in Belo Horizonte, Brazil metro area were invited to participate in the study; seven public and six private schools agreed. With parental agreement, school coordinators provided birthdates of eligible children, and envelopes containing the LDCDQ-BR (3- or 4-year-old version), ECCB, demographic questionnaire, and informed consent forms were prepared for each child. In total, 804 envelopes were distributed and 331 (41%) returned, but 19 (6%) were eliminated due to missing data. Within the 2-week period following initial completion, the LDCDQ-BR was resent to 200 parents (64% of the sample) for test-retest reliability analysis; 77 (38.5%) questionnaires (34 of 3-year-olds [20=males] and 43 of 4-year-olds [19=males]) were returned.

Of the 312 eligible respondents, parents of the first 200 recruited children were invited to bring their child for motor assessment at the child's school, with agreement obtained from 119 children (52 aged 3 [25=males]; 67 aged 4 [30=males]). The MABC-2 was administered by the first author and three occupational and physical therapy students who had received thorough MABC-2 training (Henderson et al., 2007). Interrater reliability was established before data collection with independent scoring of 10 MABC-2 children's videos, obtaining an ICC index of 0.99.

2.4 Data analysis

Statistical Package for Social Sciences (SPSS version 19.0) was used to characterize and compare groups. As the data were not normally distributed (Kolmogorov-Smirnov test), non-parametric analysis was used. Frequencies are reported for categorical variables, medians reported for continuous variables and means (with standard deviation) are reported to facilitate comparison with other studies. Dependent on variable type, Chi-square or Mann-Whitney tests were used to identify differences between 3- and 4-year-old children regarding gender, type of school, participation in extra-class motor activities, as well as differences in the motor measures, MABC-2 percentile and LDCDQ-BR raw total and sub-scores. Jeffreys's Amazing Statistics Program (JASP version 0.16) was used to estimate effect size (ES) by rank biserial correlation, interpreted as: <.30=small, .30-.50=moderate, .50-.60=large and >.80 very large effect (Portney, 2020).

Rasch analysis, Andrich's (1978) model, was used to evaluate the quality of the items and rating scale using Winsteps (version 4.5.5) (Linacre, 2020). The Rasch model has been used to strengthen the measurement qualities of several assessment tools used with children (Campbell, Kolobe, Osten, Lenke, & Girolami, 1995; Russell et al., 2000; Haley et al., 2011; Darr, Franjoine, Campbell, & Smith, 2015).

The model expects that children with good motor skills are more likely to receive high scores on all items in the questionnaire, while those with poor motor skills are likely to score well on the easiest items but fail the more difficult ones. When these assumptions are met, the items combine to measure a unidimensional construct establishing a continuum of motor skill, defined by the items calibrated at different levels of difficulty. The analysis yields several parameters to assess different aspects of the reliability and validity of the measures.

Initially, item difficulty calibrations for the 3- and 4-year-old questionnaires were compared. Differences of more than 0.5 logits (Linacre, 2020) in individual item calibrations between the two questionnaires (Differential Item Functioning - DIF) would make combined data analysis inappropriate. Next, the frequency of use of each score´s and transition points from one category to an adjacent one, Andrich thresholds, were verified. Categories should be ordered in increments, with a separation of 1.4 logits between them (Bond, Yan, & Heene, 2021). Fit of the LDCDQ-BR to the Rasch model was assessed as follows: items or children with infit and outfit MnSq>1.30 and t>2.0 were considered as misfitting (Bond et al., 2021). A questionnaire is considered valid if no more than 5% of the items and respondents/children misfit the model (Magalhães, Fisher, Linacre, & Bernspang, 1996), which in a 15-item questionnaire means no more than one misfitting item. Reliability indexes, which in Rasch analysis refers to the reproducibility of the hierarchy of item difficulty calibration and of the children's ability measures, should be >.90 for item calibration and >0.80 for children’s measures (Linacre, 2020). Separation values (G), an estimate of the spread of the items’ difficulty and persons’ measures on the measured variable, are used to calculate the number of levels or strata in which the items’ difficulty and children´s measures are divided ([4G + 1]/3) (Bond et al., 2021). For a useful measurement tool, the items must spread at least three stata (i.e., low, medium and high difficulty) and divide the children into at least two strata (Bond et al., 2021; Portney, 2020) - with and without motor deficit, but more ability levels implies more precision.

For unidimensionality analysis, three parameters were adopted (Bond et al., 2021): (a) the number of misfitting items, as specified before; (b) point biserial correlation between items and total score should be above 0.50; and (c) principal component analysis (PCA) of residuals: it is expected that the main dimension of PCA explains at least 50% of the variance in the measures, that the eigenvalue of the first residual component does not exceed the value 2 as it could indicate a possible second dimension. When the scale is unidimensional, qualitative analysis of the items’ calibration from the easiest to the most difficult one informs about construct validity. The Wright´s child-item-map was used to visualize the relationship between item difficulty and children's ability along the continuum of motor skill. As the mean item calibration is set to zero, the distance between the means for item calibration and children’s measures indicates the degree of mistargeting of the instrument (Bond et al., 2021).

Based on CTT, to confirm reliability, the LDCDQ-BR’s internal consistency coefficient Cronbach's alpha was calculated, with expected values between 0.70–0.90 (Streiner, Norman, & Cairney, 2015). Test-retest reliability was verified using ICC, with values >0.75 expected for good reliability (Portney, 2020). Spearman's correlation (rho) was used to verify concurrent validity with the MABC-2, interpreted as follows: <0.2 little or no correlation, 0.25-0.50 weak, 0.51-0.75

moderate, and >0.75 excellent correlation (Portney, 2020). Considering previous studies on concurrent validity between the LDCDQ and MABC-2, correlations were expected to vary from weak to moderate (Cantell et al., 2018; Venter et al., 2015). Finally, the MABC-2 classification of motor deficit as ≤15th percentile was used to build the ROC curve and to estimate the cut-off point for the LDCDQ-BR. Estimate accuracy was verified by the value of the area under the curve (AUC), with values between 0.50-0.70 considered low, 0.70-0.90 moderate, and >0.90 high (Streiner, Norman, & Cairney, 2015). The best cut-off point was calculated using the highest value of the Youden Index (J), which uses the formula sensibility+specificity-1 to identify the cutoff that maximizes diagnostic precision, or the best LDCDQ-BR score to identify failing in the MABC-2 (Ruopp, Perkins, Whitcomb, & Schisterman, 2008). The required values for sensitivity (i.e. number of true positives) and specificity (i.e. number of true negatives) are ≥0.80 and 0.90 (APA, 2013), respectively, for an adequate screening tool. A Type-I error probability of .05 was used in all analyses.

3. RESULTS

Raw total and sub-scores of the LDCDQ-BR by age, gender, and type of school are presented in Table 2. No significant gender differences were found on the total and sub-scores of the LDCDQ-BR, except CDM, which was better in boys (p=0.007). Children from public schools had significantly lower medians in all LDCDQ-BR scores, with small effect sizes. Children from either public or private schools who participated in extra-class motor activities (median=69) had higher LDCDQ-BR scores (U=12007.50, p=0.048, ES=0.139) than children who did not participate in these activities (median=68), with small effect size.

Table 2: LDCDQ-BR scores according to age, gender, and school type

	3 years (n=154)	4 years (n=158)	U	p value	ES
LDCDQ-BR Total					
Median/M±SD	68.00/66.48(±8.08)	68.00/65.96(±9.40)	12181.50	0.928	0.001
CDM					
Median/M±SD	22.50/21.49(±3.59)	23.00/21.82(±3.37)	11680.00	0.485	-0.040
FM					
Median/M±SD	24.00/22.92(±2.74)	24.00/22.82(±3.51)	11487.50	0.374	-0.056
GC					
Median/M±SD	23.00/22.29(±2.93)	23.00/21.84(±3.56)	12764.50	0.402	0.049
Gender	**Boys (n=158)**	**Girls (n=154)**			
LDCDQ-BR Total					
Median/M±SD	69.00/66.56(±8.22)	68.00/65.87(±9.31)	12511.00	0.664	0.028
CDM					
Median/M±SD	23.00/22.13(±3.17)	22.00/21.18(±3.73)	14288.50	**0.007**	0.174
FM					
Median/M±SD	24.00/22.69(±3.11)	24.00/23.05(±3.19)	10891.00	0.093	-0.105
GC					
Median/M±SD	23.00/22.06(±3.18)	23.00/22.06(±3.37)	11943.50	0.777	-0.018
Type of school	**Public (n=155)**	**Private (n=157)**			
LDCDQ-BR Total					
Median/M±SD	66.00/64.04(±9.92)	70.00/68.37(±6.83)	8538.50	**0.001**	-0.298
CDM					
Median/M±SD	22.00/21.12(±3.83)	23.00/22.19(±3.02)	10057.50	**0.007**	-0.173
FM					
Median/M±SD	23.00/22.17(±3.64)	25.00/23.55(±2.48)	8918.00	**0.001**	-0.267
GC					
Median/M±SD	22.00/21.28(±3.69)	24.00/22.83(±2.57)	8941.00	**0.001**	-0.265

U=Mann Whitney test; p values in bold indicate significant difference; ES=Effect size (rank biserial correlation).

3.1 Rasch analysis

3.1.1 Scoring scale and item functioning

Differences in items' calibration for the 3- and 4-year-old LDCDQ-BR questionnaires ranged from -0.40 to 0.35, suggesting no differential item functioning (DIF) or age bias. As a result, data of the two ages were combined for analysis. Analysis of scoring criteria showed that category 1 (poor motor performance) was underutilized (2%) while categories 4 (23%) and 5 (64%) (age-appropriate motor performance) were predominant, signaling high motor skills of the participants. The transition between the scores (Andrich thresholds) are ordered, albeit with a smaller than ideal distance (-1.16; -0.16; 0.04; 1.28).

Individual item analysis (Table 3) showed that only one item (#15: sits straight) had erratic scores, with a tendency for low scores in this item, even in the presence of good motor skills. The most difficult item was item 2 (catches a ball), followed by item 15 (sit straight), and two other ball items, #3 (kicks) and #1 (throws). The easiest items were #5 (moves), #13 (uses playground equipment) and #9 (posts coins). The items' reliability was excellent (0.97), indicating stability of item calibrations, with separation index of 5.95 or a spread of 8.27 levels of item difficulty. The children measures' reliability was below expected value (0.72), with a separation index of 1.60, which means 2.46 strata or basically two distinct levels of motor ability (with and without motor difficulty). Reanalysis of the data eliminating the misfitting item 15 resulted in drop in the items' reliability (0.70) instead of improvement, this way, considering this is a clinically relevant item for the identification of postural difficulties, the item was maintained in subsequent analyses.

3.1.2. Unidimensionality

No item had a point biserial correlation below 0.50, and since only one item (#15) did not fit the Rasch model, partial criteria for unidimensionality were reached. Residuals PCA, on the other hand, indicated that the items explain 46.8% of the variance in the measurements, with the possibility of two dimensions or sub-scales (eigenvalue 1st factor=2.27, explained variance of 1st residual factor=8.1%): one gross motor (#1-5, 13, 14) and another fine motor (#6-12, 15). Reanalysis with the items of each sub-scale separately showed a decrease in reliability to 0.62 and 0.55 for the gross motor and fine motor factors, respectively, while the number of children with maximum score increased over 15% (i.e. ceiling effect) (Terwee et al., 2007). Separate analysis of the three sub-scales suggested in the original questionnaire (CDM, FM, and GC) also resulted in a noticeable drop in reliability (0.61, 0.60, and 0.44, respectively) and an increase in the number of maximum scores, with ceiling effect in all sub-scales. Considering that partial criteria for unidimensionality were met and that useful sub-scales were not supported, we maintained the LDCDQ-BR as a single scale and only the total score was reported, with calibration values, respective errors, and fit-statistics shown in Table 3. Considering the 15 items, there was no evidence of local dependency (correlations of residuals 0.10-0.32). Figure 1 presents the child-item map, which represents the average calibration of the items and their relationship with the children's motor skill levels. The mean ability measure was 2.41 logits above the mean item difficulty calibration, and 31 children (9.9%) achieved a maximum score.

Table 3 – LDCDQ-BR item difficulty calibration and descriptive statistics

		Calibration (logits)	SE (logits)	Infit		Outfit	
				MnSq	**T**	**MnSq**	**t**
Difficult ↑	**02. Catches a ball**	1.31	0.07	1.28	3.13	1.33	3.13
	15. Sit straight	0.87	0.07	**1.47***	**4.51***	**1.43***	**3.65***
	03. Kick a ball rolled	0.40	0.08	1.08	0.79	1.04	0.37
	01. Throws a ball	0.38	0.08	0.87	- 1.27	0.92	- 0.60
	14. Seems to be coordinated	0.37	0.08	1.11	1.08	1.12	1.00
	10. Sticks stickers	0.20	0.09	0.78	- 2.21	0.85	- 1.17
	11. Building games	0.17	0.09	0.90	- 0.92	0.90	- 0.73
	08. Hold a pencil	- 0.08	0.09	0.88	- 1.07	0.68	- 2.46
	12. Imitates body positions	- 0.23	0.10	0.97	- 0.25	0.97	- 0.17
	04. Run	- 0.28	0.10	1.15	1.22	1.06	0.42
	06. Drink from a cup	- 0.33	0.10	1.01	0.12	0.91	- 0.55
	07. Use cutlery	- 0.36	0.10	1.30	2.32	1.13	0.85
	05. Moves from one place to place	- 0.64	0.11	0.85	- 1.18	0.79	- 1.18
	13. Uses playground equipment	- 0.78	0.12	1.00	0.01	0.86	- 0.72
Easy ↓	**09. Able to place coins in a bank-box**	- 1.01	0.13	1.01	0.15	0.65	- 1.83

Note: SE=standard error. *Items that do not fit the Rasch Model (MnSq> 1.3 and t> 2.0), in the infit and outfit statistics.

Figure 1 – Child-item map of the LDCDQ-BR

```
MEASURE   CHILD  - MAP -  ITEM
<more motor ability>|<more difficult>
   5   .##########  +
                    |
                    |
                    |
                   T|
                    |
       ###########  |
   4                +
                    |
                    |
                    |
          ########  |
                   S|
                    |
   3        ######  +
                    |
           .######  |
                    |
             #####  |
                    |
           .###### M|
   2       .######  +
               .##  |
            .#####  |
              .###  |
             .####  |
            ######  |  DCDQ2-Catches a ball
              ####  |T
   1         #####  +
              .### S|  DCDQ15-Sits up straight
                .#  |
                .#  |S
                 #  |  DCDQ14-Well coordinated    DCDQ1-Throws a ball    DCDQ3-Kicks a ball
                    |
                 .  |  DCDQ10-Sticks stickers      DCDQ11-Building games
   0             .  +M
                 .  |  DCDQ8-Holds pencil
                .# T|  DCDQ12-Imitates    DCDQ4-Runs   DCDQ6-Drink     DCDQ7-Uses cutlery
                 #  |
                    |S
                 .  |  DCDQ13-Uses playground   DCDQ5-Moves
                    |
  -1                +  DCDQ9-Post coins
                    |T
                    |
                    |
                    |
                 .  |
                    |
  -2                +
                    |
                    |
                    |
                    |
                    |
                 .  |
  -3                +
<less motor ability>|<Easier>
```

Note: The motor skill continuum is illustrated by the vertical line. Children are represented to the left of the line and items to the right. Each "#"=3 children: each "."=1 to 2 children. The M on the left represents the mean measure of children and the M on the right the mean item calibration.

3.2 Reliability

Cronbach's alpha internal consistency with all items in the analysis was 0.91, varying from 0.89 to 0.91 if any item was removed. Test-retest reliability ICC for the total LDCDQ-BR score was 0.78, and ranged from 0.44 to 0.78 for individual items. All ICC values are shown in Table 4.

Table 4 - Test-retest reliability ICC of the total score and each individual item.

Items[a] of LDCDQ-BR (n=77)	Mean score Test (SD)	Mean score Retest (SD)	ICC*
Total score	66.26(9.56)	67.40(8.71)	0.78
01. Throws a ball	4.35(0.91)	4.48(0.77)	0.57
02. Catches a ball	3.88(1.15)	3.97(0.93)	0.49
03. Kick a ball rolled	4.44(0.83)	4.48(0.88)	0.44
04. Run	4.68(0.67)	4.71(0.70)	0.60
05. Moves from one place to place	4.68(0.65)	4.71(0.66)	0.78
06. Drink from a cup	4.47(0.98)	4.56(0.78)	0.78
07. Use cutlery	4.49(0.88)	4.61(0.69)	0.62
08. Hold a pencil	4.53(0.86)	4.58(0.75)	0.64
09. Able to put a coin in the safe	4.78(0.59)	4.74(0.61)	0.56
10. Sticks stickers	4.38(0.97)	4.45(0.80)	0.69
11. Building games	4.40(0.96)	4.44(0.80)	0.61
12. Imitates body positions	4.52(0.86)	4.49(0.73)	0.55
13. Use the playground	4.62(0.76)	4.70(0.68)	0.66
14. Seems to be coordinated	4.17(1.01)	4.23(0.95)	0.59
15. Sit straight	3.92(1.14)	4.22(0.92)	0.63

[a] Items were shortened to fit the table; *p< 0.001 for all ICCs.

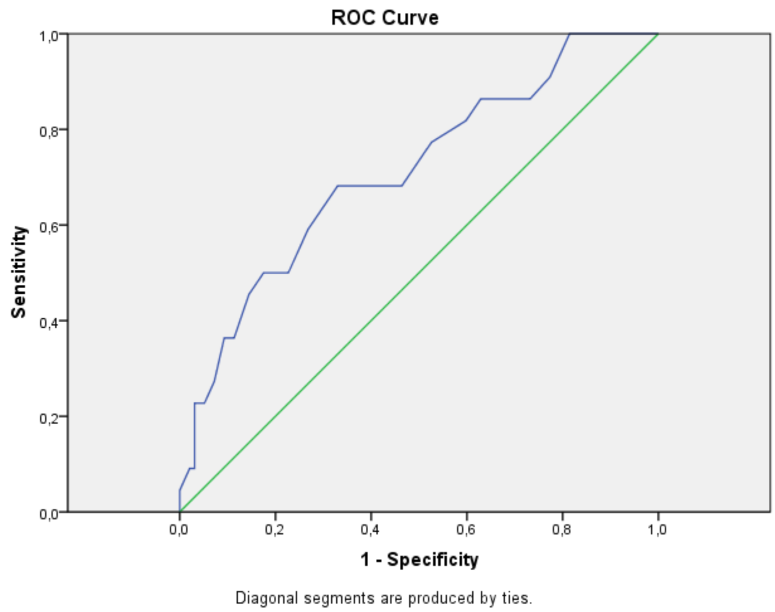
3.3 Concurrent validity

The LDCDQ-BR total score had low but significant correlation with the MABC-2 total percentile (r=0.30, p<0.01). Its correlation with MABC-2 sub-scores varied: manual dexterity r=0.28 ($p<0.001$), aiming and catching r=0.09 ($p>0.05$), and balance r=0.20 ($p<0.05$). Among the children assessed with the MABC-2, the 23 (median=62/mean=60.83 ± 9.25) who scored below the 15th percentile presented significantly lower total scores (median=68/mean=68.89 ±6.88) on the LDCDQ0-BR as compared to children who scored above it (U=2208.0, p=0.001, ES=1.0).

3.4 ROC curve and cut-off points

ROC curve (Figure 2) was calculated for the total of 119 participants assessed with the MABC-2, of which 23 were positive for motor deficit (≤ 15th percentile). The y-axis represents the positives rate (identifying children with motor deficit [sensitivity]) and the x-axis the false positives rates (1-specificity). The area under the curve (AUC) was 0.712 ($p<0.05$). The sensitivity and specificity values generated by the ROC curve ranged from 21 to 92%. The best cut-off point using the index J=0.35 was the score 64 on the LDCDQ-BR, with a sensitivity of 68% and specificity of 67%. The cut-off point was the same when calculated for private and public schools separately; there was no significant difference (p=0.818) in the percent of children positive for motor deficit in public (7,1%) versus private (7,6%) schools.

Figure 2 – LDCDQ-BR ROC curve for 119 boys and girls.



4. DISCUSSION

Early identification of children with motor difficulties can contribute to preventing secondary problems associated with DCD during adolescence and adulthood (Blank et al., 2019). This study investigated the validity and reliability of the LDCDQ-BR, a questionnaire to identify DCD risk in preschoolers. This is the first study to use the Rasch model to assess the LDCDQ measurement qualities.

A particular strength of this study lies in the recruitment of children from public and private schools resulting in a diverse socio-economic sample (levels A-E). However, more participants were recruited from upper economic classes (A and B) than the actual distribution in Brazil. The respondents' educational level also covered a wide range, with a predominance of secondary and higher education, which is above the Brazilian population average educational level (IBGE, 2020).

This was necessary as parents needed to have sufficient reading capacity to complete questionnaires.

As in previous studies (Cantell et al., 2018; Wilson et al., 2015), children's age did not affect the LDCDQ-BR total and sub-scores, and there was no age related differential response (DIF) on individual items. This was expected, as only two consecutive ages were analyzed, and the LDCDQ-BR instructs parents to consider their child´s performance in relation to other children of the same age and gender. There was also no gender difference (p=0.819) in the LDCDQ-BR total score, except for a single difference in the CDM subcategory, in which boys out-performed girls. This result may reflect the fact that in Brazil boys are more encouraged to do activities that involve movement, such as soccer. Despite CDM gender differences, the use of sub-scores was not supported given the presence of a ceiling effect, which yielded sub-scores that are not efficient to separate children in at least two motor performance levels, as required for a measurement tool (Bond et al., 2021).

An important finding of this study is that children from private schools obtained higher scores, both in the LDCDQ-BR total and sub-scores (Table 2). In Brazil, private schools usually offer more stimulating environments and activities for motor development (Queiroz et al., 2016). Furthermore, more children from private schools (52.2%) participated in extra-class motor activities, compared with children from public schools (10.9%). Extra-class activities are mostly parent-funded and are often not accessible to lower-income children who attend public schools. Together, these data suggest that differences in opportunities for motor experiences may start in preschool, with an impact on the child's motor development.

Rasch analysis identified LDCDQ-BR's strengths and weaknesses. The scoring system, with a rating scale from 1 to 5, showed increments of difficulty, but with very limited use of category 1 (2%) (poor motor performance) and overuse of categories 4 (23%) and mostly 5 (64%) (age-appropriate motor performance). This likely happened because most of the participants were children without motor difficulties, with 31 (9.9%) participants presenting maximum score. The analysis confirms the original design of the LDCDQ (Rihtman et al., 2011), which comprises items that represent everyday activities that are not very challenging for typically developing children. Even with easy items, there was no ceiling effect for the total score, as less than 15% of the children received maximum score (Terwee et al., 2007). The predominance, however, of high scores reduced the variability with impact on the reliability of the children's measures (0.72), which was lower than the required criteria (0.80), meaning more error, but still separated the participants into two distinct levels of motor ability. For children with a maximum score, the estimated motor performance measure informs that the child can perform the 15 LDCDQ-BR items, but the items do not assess the upper limit of their motor skills. Considering that this is a screening questionnaire with the goal of identifying children with a possible motor deficit this is unlikely to pose a problem.

Overall analysis of the questionnaire shows that the items fit the Rasch model, suggesting that they are well written and combine to measure a unidimensional construct (Bond et al., 2021). Only item #15 (sits straight) was erratic, with parents scoring this item inconsistently compared to response patterns of other items (Bond et al., 2021). This is a clinically relevant item which aims to identify signs of low postural tone, a very common characteristic in children with DCD (Biotteau et al., 2019). For parents, however, it seems to be challenging to distinguish between difficulty in maintaining the posture from the natural tendency of young children to prop themselves leaning forward or sideways when undertaking sitting activities. Although item #15 was revised to respond to comprehension issues identified during pilot-test interviews, these difficulties appear to persist. The possibility of adjustment or replacement could be considered, but we chose to keep it in the

LDCDQ-BR, due to the relevance of the skill it represents. Moreover, the reanalysis of the questionnaire without this item did not result in an improvement in its overall quality. Therefore, we recommend that parents be guided as to what they must observe to score it correctly.

The construct validity of the questionnaire was supported, as item calibration hierarchy seems within expectation. Ball skill items (#1,2,3), found to be the hardest, are indeed challenging for children with DCD, as they are often present in assessment tools (Henderson et al., 2007, Missiuna, Gaines, & Soucie, 2006) and mentioned as intervention goal (Araújo, Cardoso, & Magalhães, 2017). The easy items (#5,9,13) require simple fine and gross motor skills, such as placing a coin in a pig bank, moving around and using a playground.

Although the items combine to measure a unidimensional construct, PCA of the residuals indicated that the items explain only 46.8% of the variance in the scores, suggesting the possibility of two dimensions (gross motor and fine motor). These two dimensions were reanalyzed separately, but it did not support the use of two sub-scores. The LDCDQ was developed with three sub-scores in mind: CDM, FM, and GC, created by grouping items based on the opinion of experts to mirror the DCDQ'07, without data support (Rihtman et al., 2011). Subsequent studies using CTT showed varying results. Wilson and collaborators (2015) found only two dimensions, which explained 60% of the variance, with all 15 items discriminating between groups (typically and at risk). The Dutch version of the questionnaire (Cantell et al., 2018) identified three dimensions, but with a different grouping of items from the original. In the present study, Rasch analysis showed that the original proposition of three dimensions results in ceiling effect and significant drop in reliability, making sub-score use inappropriate. Although the reason for these differences is unclear, Cantell et al. (2018) draw attention to possible cultural differences in the activities represented by the items in different countries. The reason for these variations should be investigated, meanwhile, we recommend the use of the total score instead of the sub-scores to screen for motor deficits in Brazilian preschoolers.

Internal consistency (0.91) results using CTT support previous reliability studies, which have demonstrated good to excellent internal consistency rates (0.80–0.97) (Cantell et al., 2018; Rihtman et al., 2011; Venter et al., 2015; Wilson et al., 2015). Total score test-retest reliability was also good (ICC=0.78), but lower than values found for other versions, which obtained excellent reliability (0.90 and 0.96) (Rihtman et al., 2011; Wilson et al., 2015). For the LDCDQ-BR, only three items met the criteria for good test-retest reliability, while others had low to moderate values. The item with the lowest reliability was “kick a rolled ball” (ICC=0.44). As this item was not erratic in the Rasch analysis, the fluctuation in the scores between test and re-test can be attributed to the time interval for completing the questionnaire, which may have allowed parents to better observe their child kicking a ball. The expected variability in motor performance at this age (Blank et al., 2019) should be also considered.

The concurrent validity of the total LDCDQ-BR score with the total MABC-2 percentile was low but significant ($r=0.30$, $p<0.01$), similar to other versions of the questionnaire (e.g. Canadian [r=0.30], South African [r=0.2], Dutch [r=0.355]) (Cantell et al., 2018; Venter et al., 2015; Wilson et al., 2015). These low correlations are possibly related to the differences between the parent's perspective (LDCDQ) and the child's performance in a standardized test conducted by a professional (MABC-2). The nature of items is also notably different. The LDCDQ-BR is designed to represent daily activities, which explains the relatively high scores cut off points. On the other hand, the MABC-2 comprises activities that are not routine for many children, yet which discriminate those with motor coordination difficulties (Henderson et al., 2007). Additionally, most Brazilian children are not used to standardized testing. These reasons may all help to explain why the median percentile on the MABC-2 was much lower than that of the LDCDQ-BR.

ROC curve to quantify the LDCDQ-BR diagnostic accuracy for children who did the MABC-2 (n=119) had a moderate but significant area under the curve (AUC=0.712, $p<0.05$), with values similar to the Canadian and Dutch versions (Cantell et al., 2018; Wilson et al., 2015). A single cut-off point set at score 64 generated a combination of sensitivity (68%) and specificity (67%) that is below the recommended values for accurate screening purposes (APA, 2013). The proposed cut-off point is high, yet similar to the cut-off of 68 for girls and 67 for boys in Canada, and of 70 for both genders in the Netherlands, studies that also report variability in sensitivity (.40-.81) and specificity (.57-.86) values for the LDCDQ (Cantell et al., 2018; Wilson et al., 2015). Factors such as parents' difficulties in responding to questionnaires and their little knowledge of motor development (Venter et al., 2015), along with children´s little experience with standardized testing in Brazil, likely increasing their natural variability in test performance at this age (Blank et al., 2019), might have impacted the accuracy values obtained. It must be noted that in the present study there were no complaints by the parents or teachers regarding the children's motor skills; future studies should include children with suspected motor deficits or delays. Considering that the LDCDQ-BR was designed as the first step to identify young children with possible motor deficit, the clinical usefulness of the cut-off points to signalize children who may benefit from extra support or training in motor activities should be investigated.

4.1 Limitations and future studies

The expected number of participants was recruited, but it is a convenience sample comprised mostly by children without motor difficulties, with almost 10% obtaining a maximum score on the LDCDQ-BR. Studies with heterogeneous samples, with more children with motor deficits, may achieve higher reliability and separation indexes for the ability measures, reducing the margin of error in differentiating children with and without motor difficulties. The use of MABC-2 as a reference in a typically developing sample may have contributed to raising the cut-off point. Future studies should include children with motor difficulties to check suitability or necessary adjustment of the cut-off point. Sending the questionnaire home, with parents completing it without assistance, might have resulted in difficulties understanding the items. It is important to investigate whether the presence of the examiner yields better accuracy of the LDCDQ-BR score.

5. CONCLUSION

The use of a reliable and valid screening questionnaire to identify motor deficits in preschool children will enable the early identification of children who need more detailed assessment and intervention to further prevent the already known negative consequences of DCD. The LDCDQ-BR is found to be substantially unidimensional and the total score has good test-retest reliability. The questionnaire items, however, seem to represent activities that are easy for the children, reducing its potential to reliably discriminate two levels of motor skills. The use of the total score is recommended with Brazilian children and, as sensitivity and specificity values were not satisfactory, the next step is to investigate whether the cut-off point presented here is useful to identify children who need more attention for motor skills development.

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