PSYCHOMETRIC PROPERTIES OF THE REVISED DEVELOPMENTAL COORDINATION DISORDER QUESTIONNAIRE

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ABSTRACT. The Developmental Coordination Disorder Questionnaire (DCDQ) is a parent completed measure designed to identify subtle motor problems in children 8 to 14.6 years of age. The purpose of this study was to extend the lower age range to children aged 5 to 7 years, revise items to ensure clarity, develop new scoring, and evaluate validity of the revised questionnaire. Additional items with improved wording were generated by an expert panel. Analyses of internal consistency, factor loading, and qualitative/quantitative feedback from researchers, clinicians and parents were used to select 15 items with the strongest psychometric properties. Internal consistency was high (alpha = .94). The expanded questionnaire was completed by the parents of 287 children, aged 5-15 years, who were typically developing. Logistic Regression Modelling was used to generate separate cut-off scores for three age groups (overall sensitivity = 85%, specificity = 71%). The Revised DCDQ was then compared to other standardized measures in a sample of 232 clinically-referred children. Differences in scores between children with and without DCD provide evidence of construct validity ($\underline{F}_{(1,230)} = 81.7$, $\underline{p} < .001$). Concurrent validity is evident with the Movement Assessment Battery for Children (r = .55) and the Test of Visual Motor Integration (r = .42). The Revised DCDQ can be considered a valid clinical screening tool for children.

KEY WORDS: Developmental coordination disorder, screening, motor skills, parent questionnaire, assessment, validity

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Developmental Coordination Disorder (DCD) is one of the most common disorders amongst school-aged children (Wann, 2007). Despite having been featured in the literature for the better part of a century, researchers and clinicians are still developing a consensus on methods of identification and effective approaches for remediation (Leeds Consensus Statement (LCS); 2006). A number of tools have been developed which focus on identifying the presence and extent of a movement skill deficit, tested under clinical and standardized conditions, in order to meet requirements for a motor impairment as stipulated under Criterion A of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association, 2000): "Performance in daily life activities that require motor coordination is substantially below that expected by age and IQ. This may be manifested by marked delays in achieving motor milestones, dropping things, 'clumsiness', poor performance in sports or poor handwriting". Tests commonly used in North America include the Movement Assessment Battery for Children (MABC; Henderson & Sugden, 1992), the Bruininks-Oseretsky Test of Motor Proficiency (BOT; Bruininks & Bruininks, 2006), and the Beery-Buktenica Developmental Test of Visual Motor Integration (VMI; Beery, 1997; Beery & Beery, 2004).

In contrast, fewer standardized measures are available to ascertain the impact of these movement problems on functional home and school tasks, to determine whether Criterion B has also been met. Criterion B requires evidence of poor performance of daily living and academic skills, which must be measured within the context of the situation. Interviews (Geuze, 2007) and information from qualitative studies (Summers, Larkin & Dewey, 2008; Missiuna, Moll, Law, King & King, 2006) are available, and several instruments have been developed for identification of DCD by teachers (Rosenblum, 2006; Schoemaker, Flapper, Reinders-Messelink & de Kloet, 2008; Hay, Hawes & Fraught, 2004; Henderson & Sugden, 1992; Faught, et al., 2008). Parent report has been found to be useful in the process of identification of developmental and movement difficulties (Bois, Sarrazin, Brustad, Trouilloud, & Cury, 2005; Glascoe, 1999).

The Developmental Coordination Disorder Questionnaire (DCDQ; Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000) is a parent questionnaire developed to identify subtle motor problems in children from 8 to 14.6 years of age. Only one other parent questionnaire is reported in the literature (Rosenblum, 2006) but its validation was limited to a small sample ($n = 60$) of 5 to 6.5 year old children. The DCDQ requires parents to compare their child's coordination with other children of the same age and to rate it on a 5-point, labelled Likert scale. To avoid respondent bias, about half of the items are worded negatively and half positively. Total scores range from 17 to 85, with cut-off scores provided to support "an indication of DCD", "suspect DCD", or "probably not DCD". With an alpha of .88, the internal consistency of the questionnaire is high (Wilson et al., 2000). Scores for the DCDQ correlate ($r = -.59$, $p < .0001$) with scores of the MABC (Henderson & Sugden, 1992). The DCDQ also demonstrates construct validity by differentiating between children with and without DCD ($F(2, 203) = 29.43$, $p < .001$) and, through factor analysis, demonstrates that the scale measures motor skills across contexts. Table 1 shows the 17 items and four factors: Control During Movement, Fine Motor/Handwriting, Gross Motor/ Planning, and General Coordination (Wilson et al., 2000).

<Insert Table 1>

Over the past 10 years, researchers and clinicians have used the DCDQ as part of the diagnostic process (Green, et al., 2005; Schoemaker, et al., 2006; Cairney, Missiuna, Veldhuizen and Wilson, 2008). It is emerging as a valid and reliable screening instrument (Schoemaker, et al., 2008; Barnett & Peters, 2004) and one of the most convenient tools to use (Albaret and De Castelnau, 2007). Nine cross-cultural adaptations of the questionnaire have been developed and their use in some countries reported (Schoemaker et al., 2006; Traub, Levi, & Parush, 2005).

Further investigation of data from the sample used to develop the DCDQ revealed that the parents of children with Attention Deficit / Hyperactivity Disorder (ADHD) tended to rate their children as having motor problems when standardized testing did not reveal such a problem (Crawford, Wilson, & Dewey, 2001). This particular sample had a larger proportion of children with ADHD than would be expected in the general population, with consequent risk of over-endorsement bias (Kroenke, 2001). Although the DCDQ has been shown to perform adequately as a screen of motor difficulties with children with autism spectrum disorders (Green et al., submitted), further validation of the scale using a population-based sample is warranted. Several clinicians and researchers were using the DCDQ with children younger than 8 years of age, and further research would offer the opportunity to revise items and to develop scoring which included younger children. Clinicians, researchers and parents offered feedback on the clarity of items and interpretation of results, and their feedback supported the need for further refinement of the DCDQ.

The specific aims of this study were to:

1) Generate additional test items and revise several original items to ensure clarity across all ages (5 to 15 years) but with particular emphasis on validity when extending the lower age range to include children aged 5 to 7 years.
2) Evaluate the revised questionnaire with a population-based group of children without identified developmental disorders such as ADHD.
3) Determine cut-off scores which account for different ages, different genders, and different degrees of attention problems.
4) Examine internal consistency, construct and concurrent validity of the revised DCDQ with a group of children who had known developmental problems (clinically referred population).

To address the aims, the study was undertaken in four phases: I. Item Generation; II. Item Selection; III. Predictive Validity and Cut-Off Scores; and IV. Internal Consistency and Validity. Approval was received from the Child Health Research Office, the Conjoint Health Research Ethics Board at the University of Calgary, the Calgary Board of Education, and the Calgary Catholic School District for Phases II to IV in Calgary. The involvement of children from the UK in Phases III and IV was approved by the Bromley Local Research and Ethics Committee, London, England.

PHASE I: ITEM GENERATION

Participants and Procedure

A Clinical Advisory Committee (CAC) of five occupational therapists with extensive experience (5 to 20 years) working with children diagnosed with or suspected of having DCD were invited to assist in writing a research proposal and in implementing the study. Their role was to review past feedback from users, to provide feedback on the wording of new items and revision of others, to ensure that the study objectives and procedures were clinically relevant, and to provide advice on appropriate tests for confirmation of DCD. Over two and a half years, the CAC met 6 times to provide advice on the design of the study and instruments. Consensus was reached for each decision on item revision.

Results

After consideration of over 50 potential items, a 24-item research version of the DCDQ was developed for the first phase of this project. Fifteen of the original 17 items remained the same. Six additional questions were added which were similar to original items but with improved wording. One new item was added (learning to cut meat with a knife). Two of the original 17 items were slightly reworded to accommodate the skill level of younger children (e.g., “writing or printing” was replaced with “writing, printing or drawing”). Two items which were worded in the negative direction were reworded into the positive direction.

PHASE II: ITEM SELECTION

Participants and Procedure

Teachers were asked to send the 24-item research version of the DCDQ developed in Phase I home with children who, in their opinion, appeared to be of average or above average intelligence and would be considered to be “typical” developmentally. We asked them to exclude children who had developmental learning or behavior problems such as Asperger’s Syndrome and Pervasive Developmental Delay which severely interfered with academic and classroom performance, children with neurological impairments such as epilepsy and cerebral palsy, and children with visual or hearing impairments.

Questionnaires were distributed to 1899 students in 11 public schools within the four quadrants of the city of Calgary, Alberta, Canada, to obtain a cross-section of the socioeconomic strata in the city. Questionnaires were initially sent between April and June, 2004, with a stamped, addressed envelope to facilitate a higher return rate. Following distribution, both a reminder letter and then a reminder card were sent to the parents through the children’s teachers. Return rate was only 15 percent, so a second distribution was done in January 2005, also with two reminders. In total, 297 questionnaires were returned (16% return rate) and 287 had complete data (at least 20 of the 24 items completed).

The average age of the 287 children whose parents completed the questionnaire was 9.0 years (SD = 2.4; range 4.4 – 15.8). There were 155 boys and 131 girls, and one child where parents did not indicate the child’s gender.

Data Analysis

Only questionnaires that were at least 85% complete (missing 0 to 4 items) were included in the analysis. In total, 283 questionnaires had complete data, and the remaining 4 questionnaires had at least 85% complete data; mean item scores were imputed for missing values.

The strength of each item, their ability to measure the same construct, and their contribution to a test's total score was evaluated using several approaches. Cronbach's alpha and item-to-total correlations were computed to determine the degree of homogeneity among the items of the DCDQ. An overall alpha coefficient of .70 was the criterion used in this study (Bland & Altman, 1997). Items with coefficients less than .30 were not strongly related to the test as a whole and might not be making a strong contribution to the test; those above .80 are related so strongly to the total test score that they might be considered to be redundant. Therefore, items with coefficients between .30 and .80 were viewed as making the best contribution to the test. We also considered the feedback of experts who used the test, including parents. We evaluated the responsiveness of each item to measure change in functional motor skills, as part of another study (Green & Wilson, 2008).

A factor analysis (principal components with varimax rotation) was carried out to explore the relationship between items and groups of related variables to identify their contribution to the overall construct of the test. The effects of demographic factors on the total DCDQ score were investigated using a univariate ANOVA for gender and a correlation for age, with statistical significance set at $p < .05$.

Results

Internal Consistency

Cronbach's alpha coefficient for the 24 item DCDQ was .90. The alpha coefficient of the test if each item was systematically deleted measured greater than .91 (range of .91 to .92), indicating that the removal of no one item was necessary to strengthen the test. Corrected correlations between 22 of the 24 individual items and the total score were in the range of .51 to .62. The correlations of two items, however, were low: "learning to ride a bike" (.40) and "performance in team sports" (.01).

We next considered the feedback of experts and found that the lack of contribution of "performance in team sports" was consistent with other researchers, who found that this item contributed little to the test's discriminant ability (e.g., Schoemaker et al., 2006; L. de Castro Magalhães, personal communication, December 15th 2006). In another study (M.H. Tseng, personal communication, July 30th 2004), the response pattern of this item was actually reversed compared to other items and it was positively correlated with the Total Impairment Score of the MABC (while all other items were appropriately negatively correlated), indicating that this item had little consistency with the intent of the questionnaire. In addition, we took into account parents' responses when asked to list motor skills which their children took longer to learn compared with other children, which indicated the importance of items related to handwriting and sports. Thirdly, we examined the responsivity of each item based on the findings of Green and Wilson (2008), who used the DCDQ to measure change in functional motor skills at biannual periods over 2 ¼ years with repeated measures ANOVA; it was found that the "performance in team sports" item was the weakest, followed by "learning to ride a bike".

After considering all of these factors, two of the original DCDQ items were deleted ("performance in team sports" and "learning to ride a bike"). Four of the original items were replaced with items which had been revised for clarity which had the same intent but with clearer wording and higher item-total correlations ("runs and stops", "printing legible", "cuts out pictures" and "learns new motor skills"). None of the seven new items performed strongly enough and were eliminated. The revised DCDQ, therefore, included 15 items.

The revised 15-item scale was then examined for internal consistency. Cronbach's coefficient alpha was .89. The alpha of each item, if that item was deleted, ranged from .88 to .89. The deletion of any item did not increase the alpha coefficient of other items. The total score of the DCDQ was significantly correlated with each of the items of the test, a measure of individual contribution to the entire questionnaire. These item-total correlations ranged from .42 to .67 ($p < .001$).

The total DCDQ score did not differ significantly between boys and girls ($F_{(1, 284)} = 0.80$, $p = .37$) and was not correlated with child's age ($r = .09$, $p = .16$), supporting the ability of parents of both boys and girls, aged 4.4 to 15.8 years, to complete the DCDQ.

Factor Analysis

As shown in Table 2, three factors emerged with eigenvalues > 1.0, accounting for 79% of the variance. The first factor contained a number of items related to motor control while the child was moving, or while an object was in motion; it was labelled "Control during Movement". The second factor contained fine motor and handwriting/printing items. The third factor contained items related to general coordination. "Planning an activity" was the only item loading on more than one factor, and it was placed with the factor labelled "Control during Movement".

<Insert Table 2>

PHASE III: PREDICTIVE VALIDITY AND CUT-OFF SCORES

Participants

The population-based sample participating in Phase II did not have enough children with identified motor problems to adequately test the validity of the Revised DCDQ or provide the range of scores needed to carry out Logistic Regression Modelling. Therefore, two additional samples of children were included in Phase III. The sample for Phase III was derived from three sources: (A) the population-based sample described above, (B) another sample in Calgary, and (C) a sample referred for occupational therapy in England.

Sample A. Of the 287 families who returned questionnaires in Phase II of the study described here, 184 parents included their name and phone number to give us permission to contact them. We scored these 184 questionnaires according to the scoring criteria of original 17-item DCDQ and identified 30% of these children (n = 79) as being more likely to have DCD than children scoring above the 30^{th} percentile. The parents of the 69 children whom we could reach were asked if they consented to their children participating in further testing to confirm the results of the DCDQ; 55 consented. These 55 children then became part of the sample for Phase III.

Samples B and C. The remainder of the sample was comprised of 87 children with known developmental and learning problems (including DCD) who were participating in other studies in Calgary between 1992 and 1997, and 90 children with complete data (part of a sample of 98 children) in the United Kingdom (UK) who were referred for treatment of motor difficulties and who were participating in a study approved by the Bromley Local Research and Ethics Committee (Green et al., 2005; Green, 2006; Green, Chambers & Sugden, 2008).

The total sample for Phase III included 232 children (166 boys and 66 girls) with a mean age of 9.6 years. DCD was defined according to performance on three measures, as outlined in Table 3. Thirty-five of these children met criteria for ADHD (Table 4).

<Insert Tables 3 and 4 >

Procedure

Testing with the MABC and the VMI was undertaken between 1 day and 4 weeks after the DCDQ was completed, according to appropriate administration and scoring procedures by experienced occupational therapists who were masked to the results of the Revised DCDQ. The occupational therapists had experience administering the MABC and the VMI on between 50 and 100 children; their administration and scoring was observed and double checked by a second, more experienced person for accuracy. Testing took place at a children's hospital, development centre, or the child's home.

Comparison Measures

The Movement Assessment Battery for Children (MABC). This MABC assesses motor functioning across fine and gross motor tasks for children aged 4 to 12 years (Henderson & Sugden, 1992). There are four age-related subsets, each consisting of items measuring manual dexterity, ball skills, and static and dynamic balance. Items are scored on a scale of 0 to 5, with total score ranging from 0 to 40 and transformed to percentile ranks. The MABC has acceptable concurrent validity (Barnett & Peters, 2004), with correlation coefficients with other tests of .53 (BOT) and .48 (VMI) (Croce, Horvat & McCarthy, 2001; Henderson & Sugden, 1992). The test scores of children who are typically developing versus those who have learning disabilities are significantly different; test-retest reliability ranges from 73% to 97% agreement (Henderson & Sugden, 1992).

The Developmental Test of Visual Motor Integration (VMI). This test measures visual-motor abilities in children (Beery, 1997; Beery & Beery, 2004) and is the test most frequently used by therapists (Rodger, 1994). In the latest edition, two new subtests have been added: a visual perception supplemental test (no motor response required) and a motor coordination supplemental test (little visual perception required). Internal consistency for all three tests ranged from .85 to .88. Inter-rater reliability ranges from .92 to .98.

Data Analysis

In order to develop scores for the revised, 15-item DCDQ, logistic regression modelling was used to predict DCD status while accounting for factors thought to influence parent rating: age, gender and the presence of ADHD. Receiver operating characteristic (ROC) curves were also used to determine the best cut-off scores. Sensitivity refers to the percentage of children who are correctly detected as having DCD by the screening measure, the DCDQ, out of the total number of children who are considered to have DCD. Specificity is the percentage of children correctly identified without DCD, based on the DCDQ, from the total number of children without motor problems, as defined in Table 3.

Results

The results of the logistic regression, at a univariate level, indicated that DCD status was significantly predicted by the Revised DCDQ score ($p < .001$), but not by age, gender or the presence of ADHD. The same pattern of significance remained when all of the main effects were considered simultaneously in the same model: the total Revised DCDQ score was the only significant predictor of DCD status (overall $\chi^2_{(4)} = 58.69$, $p < .001$).

The next model examined all possible two way interactions (e.g., age group by gender, age group by ADHD). The overall model was significant (overall $\chi^2_{(15)} = 79.36$, $p < .001$). The total DCDQ score ($p < .05$) remained a significant predictor of DCD status, along with gender ($p < .05$), as well as several two way interactions such as gender by age group ($p < .01$). Given the complexity of this final model, separate logistic regression models for each age group division were generated, followed by ROC curves for age-specific cut-off scores to maximize sensitivity and specificity. Given that the DCDQ was developed as a screening instrument for DCD, it was more desirable to have higher sensitivity than specificity.

For children less than 8 years of age, the overall model was significant (overall $\chi^2_{(2)} = 12.85$, $p < .01$), and the total Revised DCDQ score was the best predictor of DCD status ($p < .01$). The best cut-off score to identify children with DCD or Suspect for DCD was 46 or below which resulted in a sensitivity of 75% and a specificity of 71%.

For children between 8 and 10 years of age, the overall model was significant (overall $\chi^2_{(4)} = 22.67$, $p < .001$), with the total score a significant predictor of DCD status ($p < .001$). The best cut-off score for DCD status was a revised score at or below 55. The resulting sensitivity was 89% and the specificity was 67%.

For children $\geq$ 10 years of age, the only significant predictor of DCD status was the total Revised DCDQ score ($p < .001$; overall model $\chi^2_{(1)} = 49.65$, $p < .001$). A score of 57 or below to identify children with DCD or Suspect for DCD was the best cut-off score to maximize sensitivity and specificity (89% and 76% respectively).

For the overall sample, regardless of age group, the best cut-off score for identifying DCD/Suspect DCD was a total Revised DCDQ score of 53 or below, which resulted in 81% sensitivity and 65% specificity. If the age-specific cut-offs are used, sensitivity and specificity are increased to 85% and 71% respectively (Tables 5 and 6).

<Insert Tables 5 and 6>

PHASE IV: INTERNAL CONSISTANCY AND VALIDITY

Procedure

For any between-group analyses, DCD status of the participants was divided into two categories to maximize power: DCD/Suspect DCD and nonDCD. Construct validity was assessed by comparing the mean scores on the revised DCDQ of children with DCD plus Suspect DCD to children without DCD, using ANOVA.

Results

Internal Consistency

Cronbach's alpha coefficient for the total 15 item revised questionnaire was .94, and the alpha coefficient of each item, if that item was deleted, measured was greater than .93 (range of .93 to .94) (Table 8). Corrected correlations between individual items and the total score ranged from .52 to .78, indicating strong internal consistency.

<Insert Table 7 here >

Construct Validity

The characteristics of the 232 children who were administered the MABC and VMI are presented in Table 5. The DCD plus Suspect DCD group scored lower than the nonDCD group on the total score of the 15-item Revised DCDQ [$F_{(1,230)} = 81.70$, $p < .001$], demonstrating that the Revised DCDQ measures a distinct motor construct. Three age groups emerged in the descriptive analysis of the scores across all ages, and this grouping resulted in increased sensitivity when ROC curves were examined. The groups consisted of children less than 8 years, 8 years to 9 years 11 months, and 10 to 15 years. There were no significant associations between age group and gender ($\chi^2_{(2)} = 0.32$, $p = .85$), and girls and boys did not differ on their total Revised DCDQ score ($F_{(1,230)} = 0.72$, p .40). However, age was correlated with total score ($r = .242$, $p < .001$). These results indicate that the scale is valid for use with both genders but that age-specific cut-off scores are necessary.

Concurrent Validity

Total scores for the Revised DCDQ were correlated with total impairment scores of the MABC ($r = -.55$, $p < .001$) and VMI Standard Scores ($r = .42$, $p < .001$). The correlation with the MABC is appropriately negative as the two tests are scaled in opposite directions: high MABC Impairment Scores reflect poor performance. The presence or absence of ADHD was not significantly correlated with total scores for the revised DCDQ ($r = -.11$, $p = .12$).

DISCUSSION

The results provide evidence of the validity of the revised DCDQ, supporting its use as a screening tool for developmental coordination disorder. The revised DCDQ is now appropriate for use with children as young as 5 years of age. The questionnaire has strong consistency among test items and also between item and total scores. Construct validity is evident, with scores of children with DCD or Suspect DCD being significantly different than the scores of children without DCD. No gender association was demonstrated but age was a factor in the scoring; therefore, three different cut-off scores were developed. Concurrent validity was evident in the significant correlations with tests of motor skills (MABC) and of visual-motor integration (VMI), which are moderate but consistent with the range of correlations of .40 to .60 between other tests of DCD (Barnett & Peters, 2004; Croce et al., 2001; Henderson & Sugden, 1992).

The DCDQ questionnaire includes a broad range of functional motor skills and the three factors that emerged reflect areas of motor skills known to present difficulties for children with DCD: ball skills and control during movement (Henderson & Sugden, 1992; Schoemaker et al., 2003), handwriting and fine motor skills (LCS, 2006) and general coordination including speed of movement, fatigue and the ability to learn new motor skills (LCS, 2006; Wilson, 2005).

Overall sensitivity of the Revised DCDQ, when age-specific cut-off scores are used, exceeds 84%. Specificity is lower at 71% and this is seen as appropriate for a screening instrument of this particular developmental condition, considering that other measures of DCD report specificity values which range from 62% to 66% (Faught, et al., 2008; Schoemaker et al., 2008; Schoemaker et al., 2003; Chambers & Sugden, 2002). Sensitivity of the DCDQ refers to the percentage of children who are correctly identified as meeting criteria for DCD. According to the norms of the American Psychological Association (APA, 2000), 80 percent sensitivity is preferable. Specificity is the percentage of children without problems who are correctly identified as such by a screening test, and 90% is preferable for a diagnostic test. These two values vary according to the type of sample used, and the criterion used to define the condition (Hunsley & Meyer, 2003). In addition, there is always a “trade-off” between sensitivity and specificity (Fletcher, Fletcher & Wagner, 1996). For a screening test in which early diagnosis is beneficial and when it is desirable to identify all those at risk for having DCD, high sensitivity is preferable to higher specificity. Schoemaker et al. (2003) state that screening instruments should function as a “coarse sieve” to identify all children who really have DCD, even if children without the condition are falsely identified. The risk of screening positively for a condition erroneously (i.e., a false positive diagnosis) would be corrected by confirmatory diagnostic testing with a norm referenced standardized test. In addition, it is ethically more responsible to identify more children than to miss identifying and supporting children who need services (Schoemaker et al., 2008).

When separate models and cut-off scores for each age group were examined, the highest sensitivity (over 88%) was found for the 8 to 10 year old group, which is also the age group commonly referred due to motor problems. Specificity was lowest at 67% for this group. The sensitivity of the questionnaire for children over 10 years of age was similar (89%), with specificity over 75%. The sensitivity and specificity when used with the youngest group (5 to 8 years) were moderate (75% and 71%). Although sensitivity and specificity do not meet the recommended standards for the youngest age group, the Revised DCDQ could still function adequately as a screening tool if confirmatory testing is carried out. Examination of the scores of individual items and factors of the questionnaire will also contribute to understanding the functional deficits which are required for a diagnosis of DCD.

One aim of this study was to develop scoring which accounted for gender and for the attention deficits that affect many children with motor problems. Items were carefully examined, removed or added to reduce the influence of attention on the rating of motor performance. Following these changes, gender and attention were no longer associated with DCDQ scores, resulting in a stronger instrument that will likely measure motor skills with less bias from other developmental disorders or gender.

In addition to assisting in the identification of children with DCD, this revision of the DCDQ measures functional skills in many contextual areas, thus fulfilling the requirements of Criterion B of the DSM-TR definition of DCD. While standardized tests can identify motor performance deficits (Criterion A), an instrument such as the DCDQ is needed to identify difficulties across home, school and leisure activities. No other screening tool for DCD has demonstrated similar psychometric as the DCDQ. The DCDQ is also easy to administer and score.

The DCDQ is applicable for both clinical practice and research, facilitating generalization of research results for therapeutic purposes. It is also appropriate for epidemiological studies of children with motor and other developmental problems. The DCDQ has been translated and cross-culturally adapted in many countries, including six translations of the 15-item revised version.

Continued use and adaptation of the questionnaire for other cultures will allow international collaboration and comparability of research results.

The revised version is known as the DCDQ'07 and is available for download at http://www. dcdq.ca

Limitations

Although validity of the revised DCDQ was examined by the inclusion of a population-based sample, the sample was relatively small. In addition, it was the first time children between 5 and 8 years of age were included, and further study with this group of children is indicated. Test-retest reliability was not examined in this study although results of translated versions of the DCDQ'07 are positive: M.H. Tseng (personal communication, July 30th 2004) reports a Pearson's coefficient of .94 ($p < 0.001$; $n = 35$) and L. de Castro Magalhães (personal communication, December 15th 2006) reports an Intraclass Correlation Coefficient of .97 ($n = 10$). It would be interesting to have mothers' and fathers' independently complete The DCDQ'07 to compare their perceptions of their children's motor skills. Further studies are also warranted to explore the sensitivity of the DCDQ'07 to change over time.

SUMMARY

The Revised DCDQ'07 meets many of the standards for internal consistency and for concurrent and construct validity of a screening instrument. The scoring system accounts for age differences and psychometric properties are stronger than the original 2000 version of the questionnaire, including improved sensitivity and specificity. As for all screening instruments, confirmatory testing continues to be recommended for the identification of DCD. The use of the Revised DCDQ'07, which measures functional performance across several domains within children's natural environments, fulfills the requirements of Criterion B in the definition of DCD in the DSM-TR. Use of the DCDQ'07 by occupational and physical therapists, as well as researchers, to both screen for DCD and to confirm the functional consequences of a motor deficit, will support the identification of children in need of services. The DCDQ'07 will also allow international collaboration and application of research results across cultures.

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TABLE 1. Content of Each of the Four Factors of the Original Developmental Coordination Disorder Questionnaire

Control During Movement	Fine Motor/ Handwriting	Gross Motor/ Planning	General Coordination
1. Throws ball	7. Writing fast	11. Team sports	15. Bull in china
2. Catches ball	8. Writing legibly	12. Avoid sports	16. Awkward
3. Hits ball/birdie	9. Effort & pressure	13. Ride a bike	17. Fatigues easily
4. Jumps over	10. Cuts	14. Learning skills	
5. Runs and stops			
6. Plan activity			

TABLE 2. Factor Analysis of the Revised DCDQ (Principal Component Analysis, Varimax with Kaiser Normalization).

Revised Questionnaire Item	Component		
	1. Control During Movement	2. Fine Motor / Handwriting	3. General Coordination
1: Throw	.85		
2: Catches	.85		
3: Hits	.81		
4: Jumps	.81	.31	
5: Runs	.73	.38	
6: Plans	.62	.51	
7: Writes fast		.85	
8. Writes legibly	.30	.83	
9. Effort/pressure	.38	.77	
10. Cuts	.42	.75	
11. Like sports		.36	.78
12. Learning new			.77
13. Quick/competent		.35	.75
14. “Bull”			.77
15. Not Fatigue	.33		.73

TABLE 3. Criteria Used to Define Developmental Coordination Disorder (DCD).

	MABC	**VMI-Integration**	**VMI-Motor**	**Other**
DCD	$\leq 5^{th}$ %ile	<80 Standard Score	<80 Standard Score	Two (2) out of these three measures clearly score below average
Suspect DCD	6^{th} to 15^{th} %ile	80 to 89 Standard Score	80 to 89 Standard Score	Not clearly in DCD or non-DCD ranges, but at least one score below average: $\leq 15^{th}$ %ile (for MABC) or <90 St Sc (for VMI)
Non DCD	$> 15^{th}$ %ile	≥ 90 Standard Score	≥ 90 Standard Score	All three measures clearly score within average limits

TABLE 4. Characteristics of the Sample Used to Determine Cut-Off Scores and Examine Internal Consistency and Validity of the Revised DCDQ.

	Total Sample	**# Male**	**# Female**	**Mean Age (Range)**	**# with ADHD**	**# DCD and Suspect DCD**	**# Non DCD**
2005 Sample	55	34	21	8.6 (5.1 to 15.5)	7	33	22
Original Sample	87	63	24	10.9 (8.2 to 14.3)	18	27	60
England Sample	90	69	21	9 (5.3 to 15.6)	10	76	14
Total Sample	**232**	**166**	**66**	**9.6 (5 to 15)**	**35**	**136**	**96**

TABLE 5. Sensitivity and Specificity of Revised DCDQ without Adjusting Scores for Age

	DCD or Suspect	Non DCD
DCDQ at or below cut-off	110	34
DCDQ above cut-off	26	62

Sensitivity=80.9%
Specificity=64.6%

TABLE 6. Sensitivity and Specificity of Revised DCDQ after Adjusting Scores for Age

	DCD or Suspect	Non DCD
DCDQ at or below cut-off	115	28
DCDQ above cut-off	21	68

Sensitivity=84.6%
Specificity=70.8%

TABLE 7. Internal Consistency of Items on the Revised DCDQ

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1: Throw	51.9	192.0	.77	.93
2: Catches	52.0	189.6	.76	.93
3: Hits	52.2	189.3	.77	.93
4: Jumps	51.8	189.5	.78	.93
5: Runs	51.7	191.3	.73	.93
6: Plans	51.6	193.1	.75	.93
7: Writes fast	52.3	184.8	.75	.93
8. Writes legibly	52.2	188.6	.71	.94
9. Effort/pressure	52.2	189.2	.72	.93
10. Cuts	52.0	190.8	.74	.93
11. Like sports	52.0	194.6	.52	.94
12. Learning new	52.2	193.9	.53	.94
13. "Bull"	51.8	191.0	.63	.94
14. Quick/competent	52.1	187.1	.69	.94
15. Not Fatigue	51.8	190.9	.62	.94