Evaluating the Criterion Validity of the Canadian Little DCDQ: Associations between Motor Competence, Executive Functions, Early Numeracy Skills, and ADHD in Early Childhood

Kesha N. Hudson, PhD

Michael T. Willoughby, PhD

Education & Workforce Development, RTI International, Research Triangle Park, NC, US

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Corresponding Author

Kesha Hudson, RTI International, Horizon Bldg 311F, Research Triangle Park, NC 27709; 919-316-3347; khudson@rti.org

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Abstract

The Canadian Little Developmental Coordination Disorder Questionnaire (Little DCDQ-CA) is a parent-report screening instrument that identifies 3- to 4-year-old children who may be at risk for Developmental Coordination Disorder (DCD). We tested the criterion validity of the Little DCDQ-CA in a sample of preschool-aged children in the United States (N = 233). Factor analysis resulted in a single dominant factor. Using established cut-off scores, 45% of the sample was identified as at-risk for DCD. Although a much larger percentage of children was identified as at-risk than would be expected based on the prevalence of formal DCD diagnoses in the population, the Little DCDQ-CA demonstrated good criterion validity. Children who exceeded the at-risk criterion exhibited impaired motor competence, EF, and early numeracy skills and were rated as having greater ADHD behaviors by their teachers, relative to their peers. This pattern of cognitive and behavioral deficits is consistent who those observed among children with a formal DCD diagnosis.

Keywords: Little DCDQ-CA, motor development, executive function, ADHD, early childhood

Developmental Coordination Disorder (DCD) is a common neurodevelopmental condition that affects 5-6% of children between the ages of five and 11(American Psychiatric Association, 2013). As described in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), DCD is a condition that is characterized by substantial motor impairments early in development that are not better explained by a broader medical diagnosis and result in significant and persistent difficulty with activities of daily living or academic achievement (APA, 2013). In clinical practice DCD is diagnosed on the basis of multiple sources of data including standardized tests of motor competence, such as the Bruininks-Oseretsky Test of Motor Proficiency (BOT)(Bruininks & Bruininks, 2005) or the Movement Assessment Battery for Children - Second Edition (MABC-2)(Henderson, Sugden, & Barnett, 2007), clinical observations, as well as parent- and teacher-reports of motoric skill across various contexts (Blank, Smits-Engelsman, Polatajko, & Wilson, 2012).

In comparison to typically developing children, children with DCD experience gross and fine motor difficulties that interfere with daily living skills, for example, tying shoes, using utensils, or riding a bike (Missiuna, Gaines, Soucie, & McLean, 2006; Polatajko & Cantin, 2005). In addition to motor delays, children with DCD are also likely to experience behavioral and cognitive impairments. Notably, DCD is highly comorbid with Attention Deficit Hyperactivity Disorder (ADHD). Approximately half of children who have DCD also have a concurrent ADHD diagnosis (Kaplan, Wilson, Dewey, & Crawford, 1998; Pitcher, Piek, & Hay, 2003). Empirical investigations of DCD in middle to late childhood also frequently demonstrate co-occurring cognitive impairments, including problems with executive function skills and mathematics achievement (Gomez et al., 2015; Wilson, Ruddock, Smits-Engelsman, Polatajko, & Blank, 2012). In a meta-analysis of 129 studies, Wilson et al. (2012) reported large effect sizes for comparisons between DCD and typically developing peers across the core domains of EF, including working memory (*d* = 1.07), inhibitory control (*d* = 1.03), and cognitive flexibility (*d* = 1.46) (Leonard & Hill, 2015; Zwicker, Harris, & Klassen, 2013). Similar findings have been reported across studies examining the co-occurrence of DCD and underachievement in mathematics. Deficits have been observed across several indicators of math achievement including measures of symbolic (*d* = 1.04) and non-symbolic (*d* = 1.00) number processing as well as procedural calculation (*d* = 1.44), and mental computation (*d* = 1.89) skills (Gomez et al., 2015; Pieters, Desoete, Van Waelvelde, Vanderswalmen, & Roeyers, 2012).

The cascade of persistent motor, behavioral, and cognitive deficits associated with DCD highlights the need for early diagnosis and intervention. However, due to concerns about the variability in motor skill acquisition and stability of early motor delays, DCD is not typically diagnosed prior to the age of 5, which limits opportunities for intervention during early childhood when motor and cognitive skills are rapidly developing (Blank et al., 2012). The Little Developmental Coordination Disorder Questionnaire (Little DCDQ) is a parent-report screening instrument that was developed to identify 3- to 4-year-old children who may be at risk for DCD (Rihtman, Wilson, & Parush, 2011). The Little DCDQ, is a downward extension of the DCDQ'07 (Wilson et al., 2009) and was originally developed in Hebrew and validated in Israel (Rihtman et al., 2011). The Little DCDQ and has also been translated into English and Dutch and validated in Canada (Wilson et al., 2015), South Africa (Venter, Pienaar, & Coetzee, 2015), and the Netherlands (Cantell, Houwen, & Schoemaker, 2019). The questionnaire includes 15 items, which were developed based on expert input, that were intended to quantify the motor coordination skills of young children in everyday contexts that parents routinely observed across three domains, including fine motor (e.g., *'Your child is able to peel stickers from a sheet and* *stick onto a defined space)*, general coordination (e.g., *"Your child does not fatigue easily or appear to slouch and "fall out" of the chair if required to sit for long periods*), and control during movement (e.g., *'Your child runs as fast as and in a similar way to other children of the same gender and age*).

Preliminary psychometric evidence that was provided by Rihtman et al. (2011) suggested that the Hebrew version of the Little DCDQ has promise for identifying young children who were at risk for DCD. For example, each of the three subdomain and total scores demonstrated acceptable internal consistency (Cronbach's α = .85, .84, .89, and .93 for the fine, general coordination, control during movement, and total scores, respectively). Moreover, parent ratings of children's behavior across two occasions that spanned two weeks demonstrated acceptable test-retest reliability (intraclass correlations = .84, .86, .90, and .90, for the fine, general coordination, control during movement, and total scores, respectively). Initial evidence of validity was demonstrated by significant group differences between children who varied with respect to DCD diagnostic status on each of the three subdomain scores on the Little DCDQ in relation to children's DCD diagnostic status (η^2s = .32, .42, .27 and .45 for the fine, general coordination, control during movement, and total scores, respectively).

The factor structure of the Canadian version of the Little DCDQ (Little DCDQ-CA) has also been empirically examined (Wilson et al., 2015). They reported that the 15 items were best represented by two factors (fine motor, 6 items; gross motor, 9 items), which differed somewhat from the 3 domains that were proposed by Rihtman et al. (2011) However, Wilson et al. (2015) did not describe their criteria for determining the optimal number of factors (i.e., how they determined that 2 vs. 3 factors was appropriate), and they used a varimax rotation, which assumes that factors are orthogonal. The presumption that fine and gross motor items are unrelated is questionable. Moreover, they did not comment on whether items cross-loaded on factors, which would have been expected based on expert ratings from scale developers (see Rihtman et al. 2011) Wilson et al. (2015) also developed cut-off scores to indicate risk of DCD. Although they reported that the Little DCDQ-CA was best represented by two factors, they prioritized the use of the total score for establishing at-risk cut-off values. Separate cut-off scores were proposed for boys and girls (raw sum scores of <67 and ≤ 68, respectively), which were selected to optimize sensitivity and specificity of prediction.

In an evaluation of the Little DCDQ among South African children, Venter and colleagues reported small to moderate correlations (*r*s = .15-.29) between subscale and total scores on the Little DCDQ and MABC-2 and good internal consistency (Cronbach's α =.80 - .97) across the subscales of the two measures. A cross-tabulation of the Little DCDQ and the MABC-2 demonstrated poor sensitivity (57%) but reasonable specificity (81%) (Venter et al., 2015). Cantell and colleagues reported similar findings in an evaluation of the Dutch version of the Little DCDQ. Correlations between the Little DCDQ and performance on the MABC-2 were small to moderate and increased with age (*rs* = .17 - .36). When sensitivity was held at 80% specificity increased with age but did not exceed 60% (Cantell et al., 2019).

The overall purpose of this study is to evaluate the criterion validity of the Little DCDQ-CA in a community-based sample of 3- to 5-year-old children in the United States. Given the variation in the psychometric properties reported in previous studies, we first tested the factor structure of the Little DCDQ-CA and determined the proportion of children that would be identified as at risk for DCD based on the recommended cutoff scores established by Wilson et al. (2015) Our primary research question aimed to test the criterion validity of the Little DCDQ-CA by examining whether children who met cut-off scores demonstrated a similar pattern of impairments as school-aged children who are diagnosed with DCD. Specifically, we tested whether preschool-aged children who are characterized as at-risk on the basis of parent-rated Little DCDQ-CA scores also exhibited lower motor competence, EF skills, and early numeracy skills, and greater endorsement of ADHD symptomatology relative to their peers.

Methods

Participants and Procedures

A total of 283 children (3- 5-years-old) were recruited from 67 classrooms across 14 preschools in the Southeastern United States to participate in the (study name suppressed for blind review). Parents of participating children were asked to complete the Little DCDQ-CA and teachers were asked to the Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale (SWAN)(Swanson et al., 2006). In addition, children completed direct assessments of their motor competence, EF skills, and math achievement in one-on-one assessments with project staff in preschools. This study is limited to 233 children whose parents completed the Little DCDQ-CA. Informed consent was obtained prior to participation. The (suppressed for blind review) Institutional Review Board approved all study activities.

Measures

Canadian Little Developmental Coordination Disorder Questionnaire (Rihtman et al., 2011). The Little DCDQ-CA consists of 15 items describing specific motor skills. Parents are asked to rate each item using a 5-point Likert rating scale (from 1 = *not all like my child* to 5 = *extremely like my child*). Following precedent (Rihtman et al., 2011; Wilson et al., 2015), a total score is calculated based on the sum of all items. Lower scores indicate greater motor difficulties. Seventeen parents left one item blank, most often item nine ("*your child is able to thread large beads (age 3) or small beads (age 4)*"). In order to maximize sample size, mean substitution was used to impute values for the missing item (i.e., parent mean scores across the remaining 14 items were used to determine their most likely response for the missing item).

Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale(Swanson et al., 2006). The SWAN scale consists of 18 items that measure inattention and hyperactive behavioral characteristics associated with ADHD. Teachers completed the inattention and hyperactivity subscales by comparing children to their same-age peers on skills such as focusing and maintaining attention and inhibiting impulsive behavior. Each item is measured on a 7-point Likert rating scale (from 1 = *far below average* to 7 = *far above average*). Each item is scored from -3 to +3 (below average to above average) where zero is average. Lower scores on the SWAN are indicative of greater endorsement ADHD behaviors. The reliability and validity of the SWAN is well established (Brites, Salgado-Azoni, Ferreira, Lima, & Ciasca, 2015).

Executive Function Touch (Willoughby & Blair, 2016). EF Touch is a computerized battery of seven tasks that provide performance-based indicators of preschool-aged children's inhibitory control, working memory, and attention shifting skills, as well as a brief measure of simple reaction time. The EF Touch battery has undergone extensive psychometric evaluation and there is consistent evidence that individual task measure the full range of children's ability (Willoughby, Wirth, Blair, & Family Life Project, 2012). Following precedent (Willoughby, Blair, & Family Life Project, 2016) we created an overall composite score that reflected each child's average performance across all completed tasks.

Woodcock-Johnson IV: Applied Problems Subtest (Schrank, Mather, & McGrew, 2014).

The WJ-AP, which is part of the WJ-IV battery of psychoeducational tests, is a standardized assessment of quantitative abilities consisting of a series of oral math word problems. The WJ-IV has been norm referenced using a national sample of individuals between 2 and 90 years old. Previous iterations of the WJ have been used extensively in the early childhood literature and the reliability and validity of the WJ-IV is well established (Villarreal, 2015).

Bruininks-Oseretsky Test of Motor Proficiency Short Form – Second Edition (Bruininks & Bruininks, 2005). The BOT-2 is a norm-referenced measure of motor competence. Given time constraints, we used the short form of the BOT-2, which consists of 14 items from the BOT Complete Form and takes approximately 15 minutes to complete. Example tasks include drawing a path between lines, standing with one leg on a portable balance beam, and walking along a straight line. The reliability and validity of the BOT-2 short and complete forms are well established (Bruininks & Bruininks, 2005). Raw scores were used because norm-referenced scores were not appropriate for children who were younger than 4 years of age in our sample.

Analytic Approach

We tested three questions. Our first question concerned the factor structure of the Little DCDQ-CA. Principal components analysis was used to inform the dimensionality of the Little DCDQ-CA. We considered scree plot and the number of eigenvalues greater than one to determine the optimal number of factors to retain. We subsequently estimated an exploratory factor model with an oblique (promax) rotation to inform the factor loadings and correlation between factors (if more than one factor was required). Our second question, which was primarily descriptive, determined what proportion of children in our community-based sample that would be identified as at risk for DCD based on the recommended cut-off score from Wilson et al. (2015). Our third question concerned the criterion validity of the Little DCDQ-CA cut-off score. We estimated a series of 2-level hierarchical linear models (HLM) to evaluate criterion validity. Specifically, we tested the Little DCDQ-CA risk status was uniquely associated with motor competence, executive function, numeracy skills, and ADHD symptomatology net of demographic covariates (i.e., child's age and gender; parental educational). Based on earlier work in this sample (suppressed for blind review), children's performance on a simple reaction time task was also included as a covariate in the model predicting executive function outcomes. Effect sizes (Cohen's d) were calculated to characterize the magnitude of observed differences between children who differed on Little DCDQ-CA risk status. All analyses were conducted in Stata 16.0.

Results

Participating children were an average of 4.15-years-old (*SD* = 0.63; range = 2.53 to 5.25 years) at the fall assessment. Approximately half of children were female (52.79%). The sample was racially (42% white, 36% black or African American, 9% multi-racial, 2% Asian, 1% American Indian, with 10% of parents not reporting race) and ethnically (10% Hispanic) diverse. Parental education was used to index family socioeconomic status, and 47% of parents reported attaining a 4-year college degree (or higher). Nearly one in three children in this sample were enrolled in a Head Start Center.

Factor Structure of the Little DCDQ-CA

The Little DCDQ-CA consists of 15 items on a five-point Likert scale. Item level descriptive statistics including the average score for each item and the average total score are summarized in Table 1. A principal components analysis indicated that the covariance structure of the Little DCDQ-CA items was represented by a single dominant factor. Although three eigenvalues were greater than one (eigenvalues = 6.87, 1.31, 1.09), the first explained 45.77% of the covariation in the items. Visual inspection of the scree plot also favored a single factor. We subsequently estimated three EFA models, forcing 1, 2, and 3-factor solutions (with oblique rotations). Neither the 2- or 3-factor solutions resulted in a clear, simple structure. In the 2-factor solution, seven items loaded onto factor 1, six items loaded onto factor 2, and two items cross-loaded. However, factors 1 and 2 contained both fine and gross motor items, resulting in a lack of conceptual unity. A similar pattern was observed for the 3-factor solution (i.e., items cross-loaded on multiple factors and did not exhibit conceptual unity). The standardized factor loadings from the 1-factor model ranged from .48 - .79. These results indicated that the Little DCDQ-CA was best represented by a single total factor in our sample. Cronbach's alpha was .91 with an average interitem correlation of .41. Bivariate associations between Little DCDQ-CA items are summarized in Table 2.

Descriptive Statistics

Wilson et al. (2015) established cutoff scores of ≤ 67 and 68 for boys and girls, respectively. Using these values, approximately 45% (n = 106) of our sample met the criteria for being classified as at-risk for DCD. The average total scores on the Little DCDQ-CA for children who met the risk threshold was 60.86 (*SD* = 7.34) and for children who did not meet the risk threshold was 72.39 (*SD* = 2.12) are presented in the middle and left-hand columns of Table 1, respectively. Outcomes for performance-based measures of motor competence, EF, early numeracy, and teacher endorsement of ADHD behaviors are presented in in Table 3 for the overall sample as well as for the at-risk and not at-risk subsamples.

Bivariate associations between study variables are summarized in Table 4. Three points are noteworthy. First, outcomes on performance-based measures were related to covariates in expected ways. To illustrate, child age was positively correlated with EF skills and motor competence (*rs* = .48 - .74, *ps* < .01) and parental education was positively correlated with early numeracy ($r = .29$, $p < .01$). Simple reaction time was negatively correlated with EF skills ($r = -.46$, $p < .01$). These results underscore the importance of including demographic covariates in models that examined the unique contribution of Little DCDQ-CA risk scores. Second, performance-based indicators of cognitive and motor development were moderately corelated, such that EF skills were positively correlated with early numeracy ($r = .47$, $p < .01$), and motor competence ($r = .63$, $p < .01$). In addition, teachers' endorsement of ADHD behaviors was negatively correlated with performance-based measures of EF skills, early numeracy, and motor competence (*rs* = -.24 - -.33, *ps* < .01). Finally, mean scores on the Little DCDQ-CA were positively correlated with performance-based measures of motor competence, EF and early numeracy skills (*rs* = .14 - .17, *ps* < .05) and negatively correlated with teachers' endorsement of ADHD behaviors ($r = -.20$, $p < .01$). Parents' rating of children's motor competence were not correlated with children's age, which is consistent with previously reported findings (Wilson et al., 2015).

Criterion Validity

Unconditional Models. A series of two-level (children nested in classroom) intercept-only models were estimated in order to characterize the covariance structure of our four focal outcomes (i.e., EF skills; motor competence, early numeracy, and ADHD symptomatology). In each model, both the classroom (level 2) and residual (level 1) variances were statistically significant, and intraclass correlations ranged from .23 to .49. These results confirmed the hierarchical data structure (i.e., children who shared classrooms has more similar scores than children who did not share classrooms). We continued to estimate two-level models for conditional models to ensure that all our inferences took this dependence into account.

Conditional Models. We extended the two-level models above to include predictors, including risk status as determined by the Little DCDQ-CA and covariates. As summarized in Table 5, risk status was significantly associated with worse performance on each outcome. Specifically, relative to their peers, children who met the risk cutoff exhibited poorer performance on measures of motor competence (B = -3.09, p =.002, *Cohen's d* = .28) EF skills (B = -.03, p = .046, *Cohen's d* = .21), and early numeracy (B = -5.84, p = .004, *Cohen's d* = .36) and were viewed as more hyperactive, impulsive, and inattentive by their teachers (B = -.37, p =.006, *Cohen's d* = .34). Effect sizes were of small to moderate magnitude. Graphical procedures were used to identify potential outliers or highly influential cases. Models were re-estimated removing the two most influential cases for each outcome. Substantive conclusions were unchanged, which confirmed the robustness of these results.

Discussion

We examined the factor structure and criterion validity of Little DCDQ-CA in a community-based sample of preschool-aged children in the United States. Factor analysis indicated that items were best represented by a single dominant factor. Approximately 45% of our community-based sample exceeded the at-risk cutoff score recommended by scale developers. Compared to children who did not meet the at-risk threshold, children who exceeded the at-risk cutoff performed more poorly on measures of motor competence, EF skills, and early numeracy skills and were rated as having greater ADHD behaviors by their teachers. We discuss these results in turn.

The results of the factor analysis in the current study revealed a single dominant factor, which is inconsistent with previous findings that demonstrate multi-factor solutions. In the original study by Rihtman and colleagues, the 15 items on the Hebrew version of the Little DCDQ were categorized into 3 domains of motor development with five items in each category: fine motor, general coordination, and control during movement (Rihtman et al., 2011). Importantly, this designation was theoretical and based solely on expert input. Wilson and colleagues empirically tested the factor structure of the Little DCDQ-CA and reported that the 15 items were best represented by two factors, which they labeled fine (6 items) and gross (9 items) motor (Wilson et al., 2015). Conversely, Cantell and colleagues reported a distinct three-factor solution of the Dutch Little DCDQ, including a fine motor factor (8 items), a locomotor factor (4 items), and a ball skills factor (3 items) (Cantell et al., 2019).

Although items were developed to represent a range of gross and fine motor skills relevant to 3- to 4-year-old children, the existing body of evidence suggests that they do not cohere in a consistent way across samples. Moreover, a single dominant factor suggests that Wilson et al.'s (2015) presumption that fine and gross motor items are unrelated and the use of varimax rotation in their factor analysis may have been inappropriate. These inconsistent findings across studies should spur future research to consider why a clear consensus on the dimensionality of the Little DCDQ has yet to be established. One possibility for the inconsistency is that some items ask parents to report on skills that include both fine and gross demands (e.g., *succeeds at building activities (puzzles, block towers)*). Other items are more purely related to gross motor skill (e.g., *catches large ball with both hands; runs in a manner similar to other children; seems to be coordinated*) but clearly tap different types of gross motor skills including object control skills, locomotor skills, and stability and balance skills. This interpretation is consistent with the pattern of results we observed when we forced 2- and 3-factor solutions, with several items cross-loading across factors. The evidence of a unidimensional factor structure observed in the current study conforms with the current practice of using a total score, rather than subscale scores, to establish at-risk criterion using the Little DCDQ-CA.

Approximately 45% of our sample met the at-risk criterion for DCD using the cutoff scores of Wilson et al. (2015). Given that only 5-6% of school-aged children receive formal DCD diagnoses, the Wilson et al. cutoffs appeared to over-identify children in our sample. Notably, two previous studies reported acceptable sensitivity (80% to 86%) but relatively low specificity (49% to 63%) (Cantell et al., 2019; Wilson et al., 2015). This suggests that the current cutoffs may overidentify children as at-risk for DCD who do not have motor coordination difficulties. Given that the Little DCDQ is intended to be used as a screener, it may be preferable to be over-inclusive (i.e., lower specificity) in order to maximize opportunities for identifying all children who may be at-risk for DCD. Nonetheless, the percentage of children identified as at-risk in the current study is so high that it raises questions about whether larger and more diverse normative samples should be used to create updated norms.

Consistent with previous studies (Rihtman et al., 2011; Venter et al., 2015; Wilson et al., 2015), children’s age was unrelated to their scores on the Little DCDQ-CA. Hence , parents appear able to report on the functional motor skills of their children in relation to their same age peers as directed in the instructions of the questionnaire. We observed that boys and girls exhibited comparable scores on the Little DCDQ-CA, which is consistent with initial findings reported by Rihtman et al. (2011) but inconsistent with other findings that tend to report lower scores for boys (Venter et al., 2015; Wilson et al., 2015). The lack of sex differences observed here implies that it may not be necessary to construct separate at-risk criterion for boys and girls.

The inclusion of performance-based measures of motor, cognitive, and behavioral makes the current study one of the most comprehensive evaluations of the Little DCDQ-CA to date. Our results extend the current literature on the Little DCDQ by establishing criterion validity across motor, cognitive, and behavioral outcomes. Relative to their peers, children who met the at-risk criterion on the Little DCDQ-CA performed more poorly on measures of motor competence, executive function (EF), and early numeracy skills, and they were also viewed as exhibiting more ADHD behaviors by teachers. This pattern of results provides evidence to suggest that the cascade of persistent motor, behavioral, and cognitive deficits associated with DCD may emerge early in development and underscores the need for early identification and intervention.

Our study has at least three limitations. First, we used the BOT-2 Short Form to assess children's motor competence, which has not been standardized for children younger than four years of age and necessitates the use of raw scores. As a result, we were unable to utilize standardized cutoffs for to identify children at risk for motor impairment. In addition, due to time constraints, we used the BOT-2 Short Form, which does not permit separate consideration of fine and gross motor skills. Second, we used the SWAN to measure inattention and hyperactive behavioral characteristics associated with ADHD. Teachers' endorsement of ADHD symptomatology does not constitute an ADHD diagnoses. Third, given our cross-sectional design, we were limited to reporting concurrent associations. Longitudinal designs are needed to test the predictive validity of the Little DCDQ-CA.

The results of this study indicate that the Little DCDQ-CA is a brief, parent-report screening tool that identifies individual differences in preschool-aged children's motor skills that are related to performance-based measures of motor competence, cognitive developmental, and behavioral outcomes. It seems likely that the Little DCDQ-CA cut-off scores established by Wilson et al (2015) overidentified children as at-risk in our sample. Nonetheless, these findings add to a growing body of evidence that the Little DCDQ-CA is a potentially useful screener for identifying preschool-aged children who are at-risk for experiencing motor coordination difficulties and who may benefit from a more thorough motor assessment and possibly interventions. More broadly, these findings are aligned whole child approaches to learning and development in early childhood.

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Table 1. Summary of Little DCDQ Ratings

Item	Total Sample (N = 233) M(SD)	Not At-Risk (N = 127) M(SD)	At-Risk (N =106) M(SD)
1. Throws large ball	4.27 (1.00)	4.76 (.57)	3.68 (1.09)
2. Catches large ball with both hands	3.92 (1.04)	4.40 (.78)	3.35 (1.02)
3. Kicks a ball rolled towards him or her	4.45 (.76)	4.81 (.43)	4.02 (.84)
4. Runs fast in a manner similar to other children	4.64 (.67)	4.89 (.36)	4.33 (.81)
5. Able to move from place to place and from one body position to another (e.g., on and off chairs, onto and off bed)	4.79 (.53)	4.98 (.12)	4.55 (.71)
6. Drinks from an open cup without spilling	4.67 (.66)	4.94 (.27)	4.34 (.82)
7. Uses cutlery (spoon, fork) independently	4.70 (.58)	4.92 (.27)	4.43 (.73)
8. Holds a pencil or crayon and scribbles with it (age 3) or copies simple lines and shapes (age 4)	4.35 (.88)	4.76 (.50)	3.86 (.97)
9. Able to thread large beads (age 3) or small beads (age 4)	4.11 (1.04)	4.68 (.55)	3.44 (1.08)
10. Able to peel stickers from a sheet and stick onto a defined space	4.53 (.75)	4.86 (.41)	4.14 (.87)
11. Succeeds at building activities (e.g., puzzles, block towers)	4.56 (.76)	4.92 (.32)	4.13 (.89)
12. Able to imitate body positions of others during movement activities (e.g., Simon Says, Follow the Leader)	4.56 (.74)	4.93 (.26)	4.11 (.87)
13. Uses playground equipment (e.g., climbs ladders, slides down the slide)	4.76 (.57)	4.98 (.18)	4.49 (.73)
14. Seems to be coordinated (does not fall often during the day or bump into people or objects)	4.44 (.80)	4.77 (.55)	4.04 (.86)
15. Remains sitting upright when required to sit for a period of time (does not tire easily, does not slouch)	4.40 (.85)	4.78 (.53)	3.94 (.93)
DCDQ Total Score	67.15 (7.74)	72.39 (2.12)	60.86 (7.34)

Table 2: Bivariate correlations between Little DCDQ items

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Throws ball	.40	.51	.40	.31	.37	.43	.26	.30	.29	.35	.41	.36	.32	.37
2. Catches ball with both hands	--	.40	.34	.21	.25	.26	.40	.38	.40	.27	.37	.25	.27	.27
3. Kicks ball		--	.54	.44	.47	.40	.22	.36	.36	.46	.50	.46	.33	.29
4. Runs fast			--	.63	.50	.43	.38	.26	.32	.31	.38	.54	.28	.26
5. Able to move from place to place				--	.56	.54	.46	.29	.52	.42	.50	.73	.41	.43
6. Drinks without spilling					--	.50	.36	.32	.36	.41	.49	.52	.41	.36
7. Uses cutlery independently						--	.41	.31	.41	.49	.46	.64	.38	.38
8. Holds pencil and draws							--	.59	.49	.48	.53	.43	.38	.47
9. Threads beads								--	.52	.50	.50	.33	.41	.45
10. Peels stickers									--	.41	.49	.52	.38	.40
11. Succeeds at building activities										--	.56	.56	.36	.42
12. Imitate body positions of others											--	.58	.49	.46
13. Uses playground equipment												--	.49	.48
14. Coordinated													--	.55
15. Remains upright														--

Note: All p's < 0.05

Table 3. Summary of Performance-Based Measures and Teacher Ratings

Outcome	Total Sample M (SD)	Not At-Risk M (SD)	At-Risk M (SD)
BOT-2	20.83 (11.18)	23.15 (10.93)	18.10 (10.91)
EF Composite	.60 (.14)	.62 (.13)	.57 (.15)
WJ – Applied Problems	89.87 (16.32)	92.38 (14.85)	86.93 (17.52)
SWAN	.11 (1.08)	.25 (1.03)	-.05 (1.11)

Note: M = mean; *SD* = standard deviation; BOT-2 = motor proficiency; EF Composite = executive function composite; WJ-Applied Problems = Woodcock Johnson Applied Problems; SWAN - Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale.

Table 4. Bivariate correlations between study predictors and outcomes

	2.	3.	4.	5.	6.	7.	8.	9.
1. Little DCDQ-CA	.14*	.14*	.17**	-.20**	.06	.01	.15*	-.07
2. EF Composite	--	.47**	.64**	-.27**	.48**	.15*	.07	-.46*
3. WJ- Applied Problems		--		-.33**	-.14*	.15*	.29**	-.13
4. BOT-2			--	-.24**	.74**	.06	-.07	-.53**
5. SWAN				--	.05	-.25**	-.15*	.10
6. Child Age					--	-.02	-.23**	-.55**
7. Child Gender						--	.09	.06
8. Parent Education							--	.13
9. SRT								--

Note: Little DCDQ-CA = total score; EF Composite = executive function composite; WJ-Applied Problems = Woodcock Johnson Applied Problems; BOT-2 = motor proficiency; SWAN - Strengths and Weaknesses of Attention-Deficit/Hyperactivity Disorder Symptoms and Normal Behavior Scale; SRT = Simple Reaction Time (in ms); *$p < 0.05$ **, $p < 0.01$

Table 5. Unstandardized coefficients from random effects regression models

	BOT-2	EF Composite	WJ-Applied Problems	SWAN
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Little DCDQ-CA	-3.09 (-5.02, -1.16)**	-.03 (-.06, -.00)*	-5.84 (-9.86, -1.81)**	-.37 (-.64, -.10)**
Age	13.34 (11.78, 14.91)**	.08 (.05, .11)**	-3.50 (-7.12, .11)	-.05 (-.30, .20)
Parent Educ.	.56 (.03, 1.10)*	.01 (.00, .02)**	1.63 (.45, 2.80)**	.07 (-.01, .15)
Gender	2.00 (.09, 3.91)*	.05 (.02, .08)**	4.18 (.13, 8.24)*	.58 (.32, .85)**
SRT	--	-.00 (-.00, -.00)**	--	--
N	220	216	219	226

Note: Little DCDQ-CA = total score; Parent Educ = parent education; SRT = Simple Reaction Time (in ms); *p < 0.05 **p < 0.01