Psychometric properties of the Little Developmental Coordination Disorder Questionnaire - Taiwan

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Abstract

Importance: Early identification of young children at risk of developmental coordination disorder (DCD) can support early intervention and prevent secondary sequelae.

Objective: This study examined the psychometric properties of the translated and cross-culturally adapted Little Developmental Coordination Disorder Questionnaire-Taiwan (LDCDQ-TW).

Design: Prospective study.

Setting: Parent respondents, recruited via kindergarten settings.

Participants: 1124 parents of typically developing children ages 36-71 months. Children with confirmed developmental diagnoses were excluded.

Outcomes and Measures: The LDCDQ-TW, a 15-item parent questionnaire for identifying children at risk for DCD, and the Movement Assessment Battery for Children (2^{nd} edition) (MABC-2).

Results: Findings revealed excellent test-retest reliability (ICC=0.97) and fair inter-rater reliability (ICC=0.47). Using MABC-2 scores, the non-DCD group ($\geq 15^{th}$ percentile) scored significantly higher than the DCD and suspect-DCD groups on the LDCDQ-TW, but the latter two groups did not differ. Using the 15^{th} percentile of both the MABC-2 and the LDCDQ-TW, sensitivity was 0.96 and specificity 0.68.

Conclusions and Relevance: While standardized performance-based assessments are required to confirm a DCD diagnosis (typically after the age of 5), the LDCDQ-TW demonstrated sound reliability and validity and can support the early identification of young children at risk of DCD in Taiwan.

What This Article Adds: The LDCDQ-TW questionnaire has sound psychometric properties and can be used to support early identification and monitoring of young children at risk of DCD.

Introduction

Developmental coordination disorder (DCD) is characterized by motor difficulties, resulting in physical and social participation difficulties at home, school and in the community (American Psychiatric Association, 2013; Bart, Jarus, Erez, & Rosenberg, 2011; Izadi-Najafabadi, Ryan, Ghafooripoor, Gill, & Zwicker, 2019; Jasmin, Tetreault, Lariviere, & Joly, 2018; Miyahara, Hillier, Pridham, & Nakagawa, 2017; Smits-Engelsman, Wilson, Westenberg, & Duysens, 2003; Smyth & Anderson, 2000). The reported prevalence of DCD ranges from 4-19% of school-aged children depending on the test and criteria used (Zwicker, Missiuna, Harris, & Boyd, 2012). Early childhood motor impairments associated with DCD may persist into adulthood (Kirby, Williams, Thomas, & Hill, 2013; Rasmussen & Gillberg, 2000), leading to higher rates of emotional and behavioral difficulties (Cairney, Veldhuizen, & Szatmari, 2010; van den Heuvel, Jansen, Reijneveld, Flapper, & Smits-Engelsman, 2016) increased risk for obesity (Cairney et al., 2005; Hendrix, Prins, & Dekkers, 2014), and other health-related risks (Faught, Hay, Cairney, & Flouris, 2005). Given the pervasive and long-term effects of DCD, early identification of children with suspected motor difficulties is essential to prevent secondary sequelae. In Taiwan, children between the ages of 3 and 4 years are a key group referred for early intervention support, and access to culturally suitable and age-appropriate assessment tools for this age group is of high importance.

Processes of occupational therapy assessment rely on many different types of instruments with the use of reliable and valid screening questionnaires a particularly time and cost-effective strategy (Green et al., 2005). It has been suggested that parent questionnaires may be more valid than those rated by teachers (Blank, Smits-Engelsman, Polatajko, Wilson, & European Academy for Childhood, 2012), especially for preschoolers. There are a number of motor screening questionnaires available, such as the Developmental Coordination

Disorder Questionnaire (DCDQ) (Wilson et al., 2009), the DCDDaily-Q (van der Linde et al., 2013), and Movement Assessment Battery for Children Checklist (MABC-checklist) (Schoemaker, Niemeijer, Flapper, & Smits-Engelsman, 2012), however these are mostly designed for use with children over the age of 5. The Little Developmental Coordination Disorder Questionnaire (LDCDQ) (Rihtman, Wilson, & Parush, 2011) is the only motor screening questionnaire designed for children aged from 3 to 4 years.

Information provided by parent questionnaires is consistent with a family-centered perspectives (Fingerhut et al., 2013; Green et al., 2005; Kuhanek & Case-Smith, 2000; Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000). The LDCDQ is designed for parent-rating of children's participation in ball, balance and fine motor activities across home and play environments, and has shown good reliability and validity(Rihtman et al., 2011). Therefore, the LDCDQ has the potential to be a highly appropriate screening tool as a first step in identifying preschoolers at risk for DCD.

Watson (2006) notes that, ‘concepts and information that emanate from a foreign source cannot simply be transported for use in another country, where different cultural norms exist.’ Because cultural and environmental factors influence human behavior and performance (Mendonca, Sargent, & Fetters, 2016), people from different cultural groups may differ in their response to, or performance on, the same assessment instrument. An illustration of this is that – whereas the original Hebrew LDCDQ did not reveal sex differences (Rihtman et al., 2011) – findings from the Canadian validation study did (Wilson et al., 2015). As such, researchers from more than 20 countries have translated the LDCDQ following a standard protocol and are examining its psychometric properties to obtain culturally specific norms (Cantell, Houwen, & Schoemaker, 2019; Rihtman et al., 2013; Rihtman et al., 2011; Venter, Pienaar, & Coetzee, 2015; Wilson et al., 2015). This initiative is in line with recommendations of the World Health Organization (1995) which notes that cross-cultural

translation of existing instruments provide the advantages of faster and cheaper instrument development processes while facilitating the connection of research findings from different countries. Thus, the aims of this study were to translate and cross-culturally adapt the LDCDQ into Mandarin Chinese and evaluate its psychometric properties when used with Taiwanese preschoolers.

Phase I: Translation of the LDCDQ into Mandarin Chinese

Method

Instruments

The LDCDQ is a parent screening questionnaire for children aged 36-59 months. Originally developed in Hebrew (Rihtman et al., 2011) based on the Developmental Coordination Disorder Questionnaire (DCDQ'07) (Wilson, Dewey, & Campbell, 1998), the LDCDQ asks parents to rate their children's performance on 15 positively-phrased motor activities compared to other children of the same age and gender. It uses a 5-point Likert scale ("not at all like my child" [1]; "extremely like my child" [5]). Total scores range from 15 to 75, with higher scores indicating better performance. The LDCDQ yields three sub-scores, identified using exploratory factor analysis: control during movement (CDM), fine motor (FM), and general coordination (GC). The original LDCDQ has good test-retest reliability (ICC=0.84-0.98) and internal consistency (Cronbach alpha=0.93) (Rihtman et al., 2011).

Procedures

This study received ethical approval from the XXX. As part of an ongoing cross-cultural comparison study initiated by the original authors of the LDCDQ, the questionnaire was translated into Mandarin Chinese following established guidelines (Beaton, Bombardier, Guillemin, & Feraz, 2000). Four pediatric occupational therapists (OTs)

undertook the translation, evaluated it for accuracy and amended it in accordance. Two English teachers fluent in Mandarin Chinese and English, but without knowledge of the LDCDQ, performed back-translation into English. Thereafter the back-translation was compared with the original version for semantic and conceptual equivalence. The forward-backward translation procedure was repeated until consensus was reached. The English text was sent to the lead researcher of the cross-cultural comparison study of the LDCDQ, for further feedback as to whether item meaning had been preserved. Upon confirmation, this version was pretested for item meaning and clarity with 10 preschool children and final revisions were made based on parents' feedback. The psychometric properties of this final Mandarin Chinese-Taiwan version, referred to as the LDCDQ-TW, was used in this study.

Phase II: Reliability of the LDCDQ-TW

In this phase, the internal consistency, test-retest reliability, and inter-rater reliability of the LDCDQ-TW were evaluated.

Method

Participants

Since there is no DCD screening tool for children under 72 months of age in Taiwan, and since face validity would suggest that the activities of the LDCDQ are appropriate for children up to 71 months, the age range was extended to include children between 36-71 months (n=1197). Children with neurological damage, physical or behavioral problems, diagnosis of pervasive developmental disorders, or cerebral palsy (based on parent report) were excluded, as were any questionnaires with data missing for three or more items, date of birth or sex. The final sample comprised 1124 valid questionnaires (boys: 52.8%) (n=750: Northern Taiwan; n=298: Middle Taiwan; n=76: Southern Taiwan). Participants were divided

into 6-month age bands (Table 1).

Instruments

The Little Developmental Coordination Disorder Questionnaire-Taiwan (LDCDQ-TW)

Procedures

Directors of 14 kindergartens and eight nursery schools from across Taiwan provided gatekeeper approval (n=15: Northern Taiwan; n=4: Middle Taiwan; n=3: Southern Taiwan). With their consent, 1500 questionnaires and parental informed consent forms were distributed; 1197 questionnaires were returned (response rate: 79.8%), with 73 responses excluded resulting in a sample size of n=1124. Parents/caregivers of 115 children from three kindergartens completed the LDCDQ-TW two weeks after initial completion to assess test-retest reliability. Seven kindergarten teachers were randomly selected to complete the LDCDQ-TW for 48 children to examine inter-rater reliability. Data were collected between April and November 2010.

Data analysis

A full dataset was attained for 11 items. Data were missing for four items (ranging from 0.09%-1.2%) and were imputed using sample means. SPSS 17.0 (SPSS Inc., Chicago, IL, USA) and LISREL 8.54 software were used (Joreskög & Sorbom, 2003). Two-sided $p \leq 0.05$ was considered statistically significant. Demographic data related to sex and age were analyzed using descriptive statistics. Two-way ANOVA were used to explore the effects of sex, age and their interaction (fixed factors) on the LDCDQ-TW total score (dependent variable). Cronbach's alpha (α) coefficient was computed for the LDCDQ-TW and for each factor to examine internal consistency with values >0.7 considered acceptable (Portney, 2015). Test-retest and inter-rater reliability were calculated using two-way mixed-effects model of intraclass correlation coefficient (ICC); values of >0.75, 0.5-0.75, <0.5 indicated good, moderate, and poor reliability respectively (Portney & Watkins, 2000).

Results

Sex and age comparisons

A two-way ANOVA revealed that the interaction effect of sex and age was not significant (F=0.602, p=0.698, df=5), but age (F=2.971, p=0.011, df=5) and sex (F=5.312, p=0.021, df=1) were. Girls (n=530, M=68.373±9.61) had higher scores on the LDCDQ-TW than boys (n=594, M=67.084±9.52) and older children scored higher than younger ones. Descriptive statistics of the LDCDQ-TW scores by age groups are shown in Table 1.

Internal consistency

Cronbach's α values were 0.95, 0.90, 0.92 and 0.86 for the LDCDQ-TW Total, CDM, FM and GC scores respectively, indicating good internal consistency. The values of corrected item-total correlation of the CDM, FM, and GC factors ranged from 0.65-0.82, 0.67-0.81, and 0.60-0.74 respectively (Table 2).

Test-retest reliability

Good test-retest reliability was found for the total score (ICC=0.97).

Inter-rater reliability

Inter-rater reliability between children's teachers and parents (n=48) was poor (ICC=0.47). Paired sample t-test revealed significant differences between parent (M=69.31±8.14) and teacher (M=64.77±13.75).

Phase III- Validity of the LDCDQ-TW

In this phase, the construct validity, discriminant validity, concurrent validity, sensitivity and specificity of the LDCDQ-TW were evaluated.

Method

Participants

Participants were recruited from the sample of 1124 children from Phase II. A total of

162 children participated in phase III.

Instruments

In addition to the LDCDQ-TW, the Movement Assessment Battery for Children-second edition (MABC-2) (Henderson & Sugden, 2007) was used. This is a performance-based assessment for children aged 3-16 years involving eight motor tasks in three categories: manual dexterity, aiming and catching, and balance. Test-retest reliability is 0.48 to 0.92, and inter-rater reliability varies from 0.52-1.00. The test categorizes children according to their level of motor competence: >15th percentile=without movement difficulty, 5^{th}-15^{th} percentile=at risk of having a movement difficulty; <5th percentile=significant movement difficulty.

Procedures

Kindergarten and nursery school directors acted as gatekeepers. Children who scored ≤15^{th} percentile on the LDCDQ-TW (n=167) were invited for further motor testing by qualified occupational therapists at the child's school; parents of n=74 agreed. 88 randomly selected typically developing children were also invited for MABC-2 assessment. All participants (n=162) were divided into three groups based on their MABC-2 scores, (regardless of LDCDQ-TW scores): DCD (≤5^{th} percentile), suspect-DCD (5^{th}-15^{th} percentile); non-DCD (>15^{th} percentile).

Data analysis

The original LDCDQ (Rihtman et al., 2011) contains a 3-factor model, reflecting the three subscores described above (CDM, FM and GC). To explore construct validity, confirmatory factor analysis (CFA) was employed to examine if the 3-factor model applied to the LDCDQ-TW. The χ^2 goodness-of-fit (GOF) test statistic and GOF indices were examined using Lisrel 8.5 (Joreskög & Sorbom, 2003) using a comparative fit index (CFI), non-normed fit index (NNFI), root of mean square error of approximation (RMSEA), and standardized

root mean square residual (SRMR). Value of the CFI and NNFI >0.95, the RMSEA ≤0.06, and SRMR ≤0.08 indicates good fit (Hu & Bentler, 1999).

Discriminant validity was investigated using one-way ANOVA, with Scheffe's post-hoc analyses, to compare the total LDCDQ-TW scores of the DCD, suspect-DCD, and non-DCD groups. To explore concurrent validity, Pearson's correlation coefficient were calculated to measure relationships between the LDCDQ-TW and MABC-2 total scores, with values of 0-0.3, 0.3-0.7, and 0.7-1.0 indicating weak, moderate, and strong correlations respectively (Saha & Paul, 2010).

Sensitivity refers to the proportion of children identified <15th percentile based on the LDCDQ-TW who were also classified as DCD/suspect-DCD based on the MABC-2 <15th percentile. Specificity refers to the number of children identified by the LDCDQ-TW as having cause for concern, yet not identified with motor problems based on the MABC-2 (i.e. >15th percentile). Desirable sensitivity and specificity are 80% and 90% respectively (American Psychiatric Association, 2013).

Results

Construct validity

Confirmatory factor analysis revealed a good fit for the three-factor model (CFI=0.999, NNFI=0.998, RMSEA=0.028, SRMR=0.014, χ^2=109.51, and *df*=58) (Figure 1).

Discriminant validity

Children were grouped based on MABC-2 scores (DCD [n=28], suspect-DCD [n=20], non-DCD [n= 114]). Total LDCDQ-TW scores of the DCD, suspect-DCD group, and non-DCD groups were 50.57(*SD*=7.82), 48.25(*SD*=7.39), and 63.08(*SD*=12.44) respectively. One-way ANOVA revealed significant group differences in total LDCDQ-TW scores ($F_{(2,159)}$=24.41, p<0.001) with Post hoc Scheffe's tests revealing that the non-DCD group scored significantly higher than the DCD (p<0.001) and suspect-DCD groups (p<0.001), yet

no significant differences between the DCD and suspect-DCD groups (p=0.781, *mean difference*=2.32).

Concurrent validity

The total LDCDQ-TW score showed a positive, moderate correlation with the total MABC-2 score (n=162, r=0.52, p<0.001).

Sensitivity and specificity

The criterion for DCD in our study was a score <15th percentile on both the MABC-2 and the LDCDQ-TW (Tseng, Fu, Wilson, & Hu, 2010; Wilson et al., 2000). With this criterion, sensitivity was 0.96 and specificity was 0.68.

Discussion

The LDCDQ (Rihtman et al., 2011) was translated into Mandarin Chinese and adapted for use in Taiwan (LDCDQ-TW) following rigorous procedures. This study examined the psychometric properties of the LDCDQ-TW, revealing sound validity, reliability and sensitivity.

Although the instructions of all versions of the LDCDQ asks respondents to compare the child's performance to other children of the same age and gender, suggesting that no age or gender differences would be expected, this study indeed revealed differences between groups. This finding reflects an earlier study of younger children in Taiwan which revealed that parents perceive boys to be less coordinated than girls (Tseng, Henderson, Chow, & Yao, 2004) and is consistent with several studies using the DCDQ with older children (Rivard, Missiuna, McCauley, & Cairney, 2014). On the other hand, Wilson et al. (2015) used the LDCDQ-CA with Canadian preschoolers and found that boys scored higher than girls. Although significant, the sex differences in these studies were small (1-2 points).

Our findings indicated that older children scored significantly higher than younger

children, similar to the findings of Cantell, Houwen, & Schoemaker (2019) with the Dutch LDCDQ-NL. Some activities in the LDCDQ-TW are newly learned at age 3 and children's performance may be influenced by practice. It is also possible that opportunities for practice of the activities, as well as parental perceptions and expectations regarding competent performance, differ between cultures.

Internal consistency of the three factors was good-excellent (α=0.86-0.92), a finding similar to the original Hebrew-language LDCDQ (α=0.84 to 0.89) (Rihtman et al., 2011). There were no negative or near-zero values of corrected item-total correlations, indicating that all LDCDQ-TW items contributed positively to factor scores and confirming homogeneity of items, a finding consistent with other versions of the questionnaire (Wilson et al., 2015). Confirmatory factor analysis supported the original three-factor model of the LDCDQ (Rihtman et al., 2011) with Taiwanese preschoolers.

While there was poor parent-teacher agreement on the LDCDQ-TW total score (r=0.45), this may not be surprising. This is common across many assessments (Hartman, Rhee, Willcutt, & Pennington, 2007) and may reflect observations of different types of behavior. Activities in which a child engages at home – often individually – are likely to differ from those expected at school in a group of peers. Inter-rater reliability is best assessed when all raters measure a response at the same time but independently (Portney, 2015). In this case, raters asynchronously observed different samples of behavior.

Consistent with several other studies (Rihtman et al., 2011; Wilson et al., 2015), the LDCDQ-TW identified young children at risk of a later DCD diagnosis, however, it did not distinguish between those with more or less severe motor difficulties. As the LDCDQ is an early screening tool to identify children requiring monitoring of motor development in relation to a diagnosis not usually given before the age of five (Blank et al., 2019), this is not a significant concern and does not detract from the questionnaire's intended use. With many

screening tools, it is expected that further standardized performance-based assessments be administered to confirm diagnosis and degree of severity (APA, 2013).

The LDCDQ-TW showed significant yet moderate correlations with the MABC-2 (*r*=0.52), indicating that parent observations and professional assessment of children's motor development are related (Wilson et al., 2000). However, other studies comparing the LDCDQ and MABC-2 have not found relationships of this magnitude (Venter et al., 2015: r=0.29;(Venter et al., 2015; Wilson et al., 2015) suggesting that this is an area for monitoring as further LDCDQ versions are published.

Using the 15th percentile cutoffs of both the MABC-2 and the LDCDQ-TW, specificity (68%) did not meet the preferred standard (APA, 2013), yet sensitivity (96%) did, indicating that children at risk of DCD are identified by the LDCDQ-TW with 96% accuracy. In this instance, given the importance of early identification and due to the intended purpose of the LDCDQ-TW, higher sensitivity is preferred. Despite a false positive rate of 32%, it is crucial not to miss children with motor impairment who may develop social, emotional and academic problems (Cairney et al., 2010).

This study has some limitations. Parent and teacher respondents may have limited understanding of movement development, however, it is hoped that this concern was ameliorated through the instruction to compare the child to other children of the same age and gender. Additionally, the questionnaire was designed for parents and it may be erroneous to assume similarities based on teacher report. Future inter-rater reliability studies should recruit informants from the same context, such as two different family members. Moreover, the relatively low specificity, which suggests high false positive identification, is a further limitation and is an important area to explore in further validation studies. However, considering the intended use of the LDCDQ-TW (an inexpensive first step screening), higher sensitivity could be claimed to be more important than higher specificity. The identification

of children potentially at risk of DCD as a first step using the LDCDQ-TW, followed by clinician-administered motor assessment, is recommended as part of a wider needs identification process.

Implication for Occupational Therapy Practice

Early identification of children at risk of a later DCD diagnosis can facilitate early intervention, thus preventing secondary sequelae. Occupational therapists have a central role to play in the assessment and treatment of this clinical population. Our study demonstrated that the LDCDQ-TW is a valid and reliable tool to identify young children who may be facing this risk. This has the potential to support the provision of timely intervention for young Taiwanese children with motor difficulties before secondary sequelae develop.

In addition to the clinical implications of the current study for occupational therapy practice in Taiwan, the findings also contribute to a wider international collaborative intention to understand cultural influences on motor development of young children. The LDCDQ is currently being standardized in more than 20 countries around the world following similar procedures. An initiative of this nature has implications for occupational therapy practice, across all stages of the occupational therapy process.

Conclusion

The aims of this study were to translate and cross-culturally adapt the LDCDQ into Mandarin Chinese and evaluate its psychometric properties when used with Taiwanese preschoolers. Findings revealed sound validity, reliability, and sensitivity, and borderline specificity and parent-teacher agreement. The LDCDQ-TW identifies young Taiwanese children at risk of a DCD diagnosis and can be a useful tool to support early identification and intervention.

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References

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual-5th ed. (DSM-5)*. Washington, D.C.: American Psychiatric Association.

Bart, O., Jarus, T., Erez, Y., & Rosenberg, L. (2011). How do young children with DCD participate and enjoy daily activities? *Research in Developmental Disabilities, 32*(4), 1317-1322. doi:10.1016/j.ridd.2011.01.039

Blank, R., Smits-Engelsman, B., Polatajko, H., Wilson, P., & European Academy for Childhood, D. (2012). European Academy for Childhood Disability (EACD): recommendations on the definition, diagnosis and intervention of developmental coordination disorder (long version). *Developmental Medicine and Child Neurology, 54*(1), 54-93. doi:10.1111/j.1469-8749.2011.04171.x

Cairney, J., Hay, J. A., Faught, B. E., Wade, T. J., Corna, L., & Flouris, A. (2005). Developmental coordination disorder, generalized self-efficacy toward physical activity, and participation in organized and free play activities. *The Journal of Pediatrics, 147*(4), 515-520. doi:10.1016/j.jpeds.2005.05.013

Cairney, J., Veldhuizen, S., & Szatmari, P. (2010). Motor coordination and emotional-behavioral problems in children. *Current Opinion in Psychiatry, 23*(4), 324-329. doi:10.1097/YCO.0b013e32833aa0aa

Cantell, M., Houwen, S., & Schoemaker, M. (2019). Age-related validity and reliability of the Dutch Little Developmental Coordination Disorder Questionnaire (LDCDQ-NL). *Research in Developmental Disabilities, 84*, 28-35. doi:10.1016/j.ridd.2018.02.010

Faught, B. E., Hay, J. A., Cairney, J., & Flouris, A. (2005). Increased risk for coronary vascular disease in children with developmental coordination disorder. *Journal of Adolescent Health, 37*(5), 376-380. doi:10.1016/j.jadohealth.2004.09.021

Fingerhut, P. E., Piro, J., Sutton, A., Campbell, R., Lewis, C., Lawji, D., & Martinez, N. (2013). Family-centered principles implemented in home-based, clinic-based, and school-based pediatric settings. *American Journal of Occupational Therapy, 67*(2), 228-235. doi:10.5014/ajot.2013.006957

Green, D., Bishop, T., Wilson, B. N., Crawford, S., Hooper, R., Kaplan, B., & Baird, G. (2005). Is questionnaire-based screening part of the solution to waiting lists for children with developmental coordination disorder? *British Journal of Occupational Therapy, 68*(1), 2-10.

Hartman, C. A., Rhee, S. H., Willcutt, E. G., & Pennington, B. F. (2007). Modeling rater disagreement for ADHD: are parents or teachers biased? *Journal of Abnormal Child Psychology, 35*(4), 536-542. doi:10.1007/s10802-007-9110-y

Henderson, S. E., & Sugden, D. A. (2007). *Movement Assessment Battery for Children* (2nd ed.). London: Psychological Corporation.

Hendrix, C. G., Prins, M. R., & Dekkers, H. (2014). Developmental coordination disorder and overweight and obesity in children: a systematic review. *Obesity Reviews, 15*(5), 408-423. doi:10.1111/obr.12137

Hu, L., & Bentler, P. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. doi:10.1080/10705519909540118

Izadi-Najafabadi, S., Ryan, N., Ghafooripoor, G., Gill, K., & Zwicker, J. G. (2019). Participation of children with developmental coordination disorder. *Research in Developmental Disabilities, 84*, 75-84. doi:10.1016/j.ridd.2018.05.011

Jasmin, E., Tetreault, S., Lariviere, N., & Joly, J. (2018). Participation and needs of children with developmental coordination disorder at home and in the community: Perceptions of children and parents. *Research in Developmental Disabilities, 73*, 1-13.

doi:10.1016/j.ridd.2017.12.011
Joreskög, K. G., & Sorbom, D. (2003). *LISREL 8.54: Structural equation modeling with the SIMPLIS command language*. Chicago: Scientific Software International.
Kirby, A., Williams, N., Thomas, M., & Hill, E. L. (2013). Self-reported mood, general health, wellbeing and employment status in adults with suspected DCD. *Research in Developmental Disabilities, 34*(4), 1357-1364. doi:10.1016/j.ridd.2013.01.003
Kuhanek, H., & Case-Smith, J. (2000). The occupational therapy process in pediatrics: Overview of essential concepts. In J. C. O-Brien. & H. Kuhkaneck (Eds.), *Occupational Therapy for Children* (8th ed.). St. Louis, MO: Elsevier.
Mendonca, B., Sargent, B., & Fetters, L. (2016). Cross-cultural validity of standardized motor development screening and assessment tools: a systematic review. *Develoopmental Medicine and Child Neurology, 58*(12), 1213-1222. doi:10.1111/dmcn.13263
Miyahara, M., Hillier, S. L., Pridham, L., & Nakagawa, S. (2017). Task-oriented interventions for children with developmental co-ordination disorder. *Cochrane Database of Systematic Reviews, 7*, CD010914. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/28758189
Portney, L. G. (2015). *Foundations of clinical research: Application to practice* (4th ed.). Philadelphia, PA: F.A. Davis.
Portney, L. G., & Watkins, M. P. (2000). *Foundations of Clinical Research: Applications to Practice* (3rd ed.). Philadelphia: F. A. Davis.
Rasmussen, P., & Gillberg, C. (2000). Natural outcome of ADHD with developmental coordination disorder at age 22 years: a controlled, longitudinal, community-based study. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*(11), 1424-1431. doi:10.1097/00004583-200011000-00017
Rihtman, T., Wilson, B. N., Cermak, S., Rodger, S., Schoemaker, M., Cantell, M., . . . Coetzee, D. (2013). Can a little instrument make a big noise? A cross-sectional collaboration for identifying for identifying motor delay for identifying motor delau in young preschoolers., 10th International Conference on Developmental Coordination Disorder. *Brazilian Journal of Motor Behaviour, 7 (supplement)*(24), ISSN 1980-5586.
Rihtman, T., Wilson, B. N., & Parush, S. (2011). Development of the Little Developmental Coordination Disorder Questionnaire for preschoolers and preliminary evidence of its psychometric properties in Israel. *Research in Developmental Disabilities, 32*(4), 1378-1387. doi:10.1016/j.ridd.2010.12.040
Rivard, L., Missiuna, C., McCauley, D., & Cairney, J. (2014). Descriptive and factor analysis of the Developmental Coordination Disorder Questionnaire (DCDQ'07) in a population-based sample of children with and without Developmental Coordination Disorder. *Child: Care, Health and Development, 40*(1), 42-49. doi:doi:10.1111/j.1365-2214.2012.01425.x
Saha, I., & Paul, B. (2010). *Biostatistics*. Kolkata: Academic Publishers.
Schoemaker, M. M., Niemeijer, A. S., Flapper, B. C., & Smits-Engelsman, B. C. (2012). Validity and reliability of the Movement Assessment Battery for Children-2 Checklist for children with and without motor impairments. *Developmental Medicine and Child Neurology, 54*(4), 368-375. doi:10.1111/j.1469-8749.2012.04226.x
Smits-Engelsman, B. C., Wilson, P. H., Westenberg, Y., & Duysens, J. (2003). Fine motor deficiencies in children with developmental coordination disorder and learning disabilities: an underlying open-loop control deficit. *Human Movement Science, 22*(4-5), 495-513. doi:10.1016/j.humov.2003.09.006
Smyth, M. M., & Anderson, H. I. (2000). Coping with clumsiness in the school playground:

Social and physical play in children with coordination impairments. *British Journal of Developmental Psychology, 18*(3), 389-413. doi:10.1348/026151000165760

Tseng, M. H., Fu, C. P., Wilson, B. N., & Hu, F. C. (2010). Psychometric properties of a Chinese version of the Developmental Coordination Disorder Questionnaire in community-based children. *Research in Developmental Disabilities, 31*(1), 33-45. doi:10.1016/j.ridd.2009.07.018

Tseng, M. H., Henderson, A., Chow, S. M., & Yao, G. (2004). Relationship between motor proficiency, attention, impulse, and activity in children with ADHD. *Developmental Medicine and Child Neurology, 46*(6), 381-388. doi:10.1017/s0012162204000623

van den Heuvel, M., Jansen, D. E., Reijneveld, S. A., Flapper, B. C., & Smits-Engelsman, B. C. (2016). Identification of emotional and behavioral problems by teachers in children with developmental coordination disorder in the school community. *Research in Developmental Disabilities, 51-52*, 40-48. doi:10.1016/j.ridd.2016.01.008

van der Linde, B. W., van Netten, J. J., Otten, B. E., Postema, K., Geuze, R. H., & Schoemaker, M. M. (2013). Development and psychometric properties of the DCDDaily: a new test for clinical assessment of capacity in activities of daily living in children with developmental coordination disorder. *Clinical Rehabilitation, 27*(9), 834-844. doi:10.1177/0269215513481227

Venter, A., Pienaar, A. E., & Coetzee, D. (2015). Suitability of the 'Little DCDQ' in a selected group of 3-5 year old South African children. *Early Child Development and Care, 185*, 1359-1371. doi:doi.org/10.1080/03004430.2014.1000887

Watson, R. M. (2006). Being before doing: The cultural identity (essence) of occupational therapy. *Australian Occupational Therapy Journal, 53*(3), 151-158.

WHOQOL Group. (1995). The World Health Organization Quality of Life assessment (WHOQOL): position paper from the World Health Organization. *Soc Sci Med, 41*(10), 1403-1409. doi:10.1016/0277-9536(95)00112-k

Wilson, B. N., Crawford, S. G., Green, D., Roberts, G., Aylott, A., & Kaplan, B. J. (2009). Psychometric properties of the revised Developmental Coordination Disorder Questionnaire. *Physical and Occupational Therapy in Pediatrics, 29*(2), 182-202. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19401931

Wilson, B. N., Creighton, D., Crawford, S. G., Heath, J. A., Semple, L., Tan, B., & Hansen, S. (2015). Psychometric Properties of the Canadian Little Developmental Coordination Disorder Questionnaire for Preschool Children. *Physical and Occupational Therapy in Pediatrics, 35*(2), 116-131. doi:10.3109/01942638.2014.980928

Wilson, B. N., Dewey, D., & Campbell, A. (1998). *Developmental Coordination Disorder Questionnaire (DCDQ)*. Calgary, Alta., Canada: Alberta Children's Hospital Research Center.

Wilson, B. N., Kaplan, B. J., Crawford, S. G., Campbell, A., & Dewey, D. (2000). Reliability and validity of a parent questionnaire on childhood motor skills. *American Journal of Occupational Therapy, 54*(5), 484-493. doi:10.5014/ajot.54.5.484

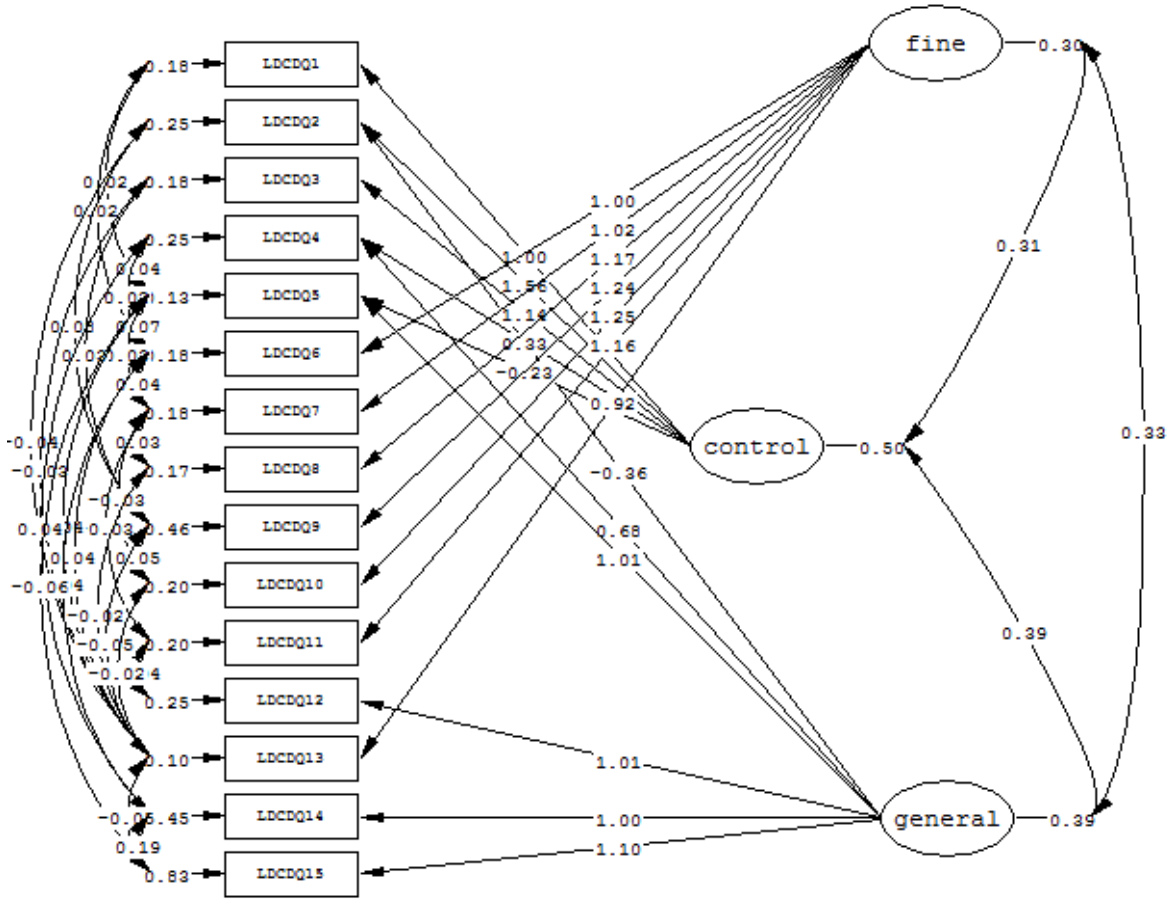
Zwicker, J. G., Missiuna, C., Harris, S. R., & Boyd, L. A. (2012). Developmental coordination disorder: a review and update. *European Journal of Paediatric Neurology, 16*(6), 573-581. doi:10.1016/j.ejpn.2012.05.005

Table 1 Demographics and LDCDQ-TW scores of the community sample. (*N*=1124)

Age group in months	Age (months) M±SD	Gender *n*	LDCDQ-TW Total M±SD	LDCDQ-TW Total M±SD
1: 36-41	39.38(1.59)	Boys: 24 Girls: 22	Boys: 63.69(9.67) Girls: 65.06(12.53)	64.35(11.02)
2: 42-47	45.37(1.68)	Boys: 47 Girls: 45	Boys: 63.87(10.43) Girls: 67.33(8.62)	65.57(9.70)
3: 48-53	51.31(1.79)	Boys: 95 Girls: 77	Boys: 65.93(8.86) Girls: 68.65(7.58)	67.15(8.40)
4: 54-59	57.51(1.74)	Boys: 124 Girls: 105	Boys: 67.13(9.22) Girls: 67.99(10.65)	67.52(9.89)
5: 60-65	62.95(1.72)	Boys: 157 Girls: 156	Boys: 68.28(9.05) Girls: 68.69(9.41)	68.48(9.22)
6: 66-71	68.70(1.72)	Boys: 147 Girls: 125	Boys: 68.10(10.13) Girls: 69.09(9.84)	68.55(10.00)
Total	59.05(8.40)	Boys: 594 Girls: 530	Boys: 67.08(9.54) Girls: 68.37(9.61)	67.69(9.59)

Table 2 Item-total correlation coefficients (*n*=1124)

Factor/Item	Corrected item-total correlation	Cronbach's alpha for each factor if item deleted
Control during movement factor		
1. Throwing a ball	0.82	0.86
2. Catching a ball	0.78	0.88
3. Kicking a ball	0.82	0.86
4. Running	0.74	0.88
5. Moving or changing postures	0.65	0.90
Fine motor/ handwriting factor		
6. Drinking	0.78	0.91
7. Eating with spoons or chopsticks	0.77	0.91
8. Scrabbling or drawing	0.81	0.90
9. Stringing beads	0.67	0.92
10. Sticking stickers	0.80	0.91
11. Puzzling or building blocks	0.77	0.91
13. Playing amusement facilities	0.78	0.91
General coordination factor		
2. Catching a ball	0.66	0.84
4. Running	0.74	0.83
5. Moving or changing postures	0.67	0.85
12. Singing and imitating movements	0.68	0.84
14. Coordination	0.70	0.83
15. Not fatigue	0.60	0.86



LDCDQ1 Throwing a ball
LDCDQ2 Catching a ball
LDCDQ3 Kicking a ball
LDCDQ4 Running
LDCDQ5 Moving or changing postures
LDCDQ6 Drinking
LDCDQ7 Eating with spoons or chopsticks
LDCDQ8 Scrabbling or drawing
LDCDQ9 Stringing beads
LDCDQ10 Sticking stickers
LDCDQ11 Puzzling or building blocks
LDCDQ12 Singing and imitating movements
LDCDQ13 Playing amusement facilities
LDCDQ14 Coordination
LDCDQ15 Not fatigue

Figure 1 The final confirmatory factor analysis model of LDCDQ-TW