CAN THE MABC DISCRIMINATE AND PREDICT MOTOR IMPAIRMENT? A COMPARISON OF BRAZILIAN AND NORTH AMERICAN CHILDREN

Original Research

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Abstract

**Background:** Estimates of the prevalence of DCD range from 1.7% to 19%, raising concerns about the discriminative ability of the Movement Assessment Battery for Children (MABC). **Aims:** We compared MABC performance of children from North America (United States - US) and Brazil ages 4- to 12-years. We aimed to examine: a) the prevalence of motor impairment across countries; b) age band and sex differences across countries; c) the test’s ability to discriminate and predict motor impairment; and d) to identify the discriminating capacity of each MABC subtest. **Methods:** Children (N=1,055) from Brazil and United States were included in the present study. MABC cut-off points (TD: above 15%, at-risk: 6 to 15%; DCD: below and at 5%) and discriminant analyses were used. **Findings:** Prevalence of probable DCD (24.1%) and at-risk (16.2) was higher in the Brazilian sample. Higher prevalence of probable DCD was observed among girls and among children 11 to 12 years old for a Brazilian sample and among boys and children 9 to 12 years old for a North American sample. Differences in scores across countries were only observed for children with TD in manual dexterity and balance skills. The MABC discriminant functions were able to predict the classification of children into TD, at-risk, and probable DCD. The manual dexterity subtest was the strongest predictor for both samples, whereas the ball skills subtest was the weakest predictor. **Conclusions:** Differences for prevalence where found across countries. North American results were similar with current estimates relative to incidence and gender; for Brazilian children, prevalence was near three times higher and more persistent among girls. Overall, in both countries the motor difficulties demonstrated by children with probable and at-risk DCD were similar for all tasks. The MABC showed predictably and discriminant capacity in the identification of children with probable and at-risk DCD in both countries.

**KEY WORDS:** DCD; MABC predictive ability; motor performance.

**Introduction**

Developmental Coordination Disorder (DCD) is characterized by deficits in fine and gross motor skills that interfere with the performance of activities of daily living (Summers, Larkin & Dewey, 2008). Although difficulties in balance control (Chen et al., 2011; Fong et al., 2015), ball skills (Przysucha & Maraj, 2010), and fine-motor tasks (Roche et al., 2011) may resolve across childhood, more often these difficulties persist throughout adolescence and adulthood in those with DCD (DSM-5, 2013). The negative impact of movement difficulties often also affects the individual’s social functioning (Poulsen et al., 2007) and their intellectual abilities (Gibbs et al., 2007).

The prevalence of DCD affect 6% of school aged children according to the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5, 2013). Interestingly, previous studies reported controversial rates for prevalence of DCD around the world, ranging from 1.7% to 19%. For example, a large study in UK reported DCD’ prevalence of 1.7% (Lingam, Hunt, Golding, Jongmans & Emond, 2009), whereas in the Netherlands and Germany the prevalence of DCD was reported around 7% (Jongman, Smits-Engelsman & Shoemaker, 2003). Also, DCD’ prevalence rates of 8% and 19% have been reported for Canadian and Greek children, respectively (Tsiotra et al*.*, 2006; Kadesjo & Gillberg, 1998). These results have raised several concerns not only about the validity of the tests being used to detect probable DCD, but also about the potential for misdiagnosis of DCD in children across countries.

Although researchers reported different prevalence rates around the world, specific motor tasks scores (i.e., balance, ball skills or fine motor skills) have not yet been reported. Lack of information regarding potential differences and/or similarities in the performance of specific tasks limit the capacity to discriminate and categorize Brazilian children accurately and make meaningful comparisons across diverse samples. Therefore, the identification of DCD by standard motor tests in Brazil raises additional concerns.

Among the various standardized motor assessments, the Movement Assessment Battery for Children – MABC (Henderson & Sugden, 1992) has been recognized as the gold standard to identify those with DCD (Venetsanou et al., 2010). The recent update to the MABC (MABC-2) currently lacks strong evidence for its validity and reliability (Venetsanou et al., 2010). Given that standardized assessments are expensive, and that the changes made in the second edition were not related to the task constructs, clinicians and researchers may choose not to use the new version until strong evidence of its criterion validity and clinical utility is shown. When a new neuropsychological test is introduced, those adopting it face significant financial, conceptual, ethical, and clinical challenges. Professionals trained to base clinical decisions on previous versions of the tests are faced with demands to use a less proven and potentially less effective measure until the availability of reasonable clinical decision-making data (Loring & Bauer, 2010). Therefore, the use of the original gold standard battery seems appropriate since its validity has been clearly demonstrated.

In this paper, we compared MABC scores obtained from North American (US) and Brazilian children from 4- to 12-years -of-age using the first edition of the battery that was available to the Brazilian sample. Specifically, we aimed to: a) explore differences in the prevalence of motor impairment across the two countries; b) examine age band and sex differences in MABC impairment scores and subtests for children across the two countries; c) examine the test’s ability to discriminate and predict motor impairment; and d) to identify the discriminating capacity of each subtest of the MABC.

**Method**

*Participants*

MABC scores were obtained from 1,055 data sets from children born in Brazil (BR: N=697) and United States (US: N=358). Participants were 4- to- 12 years-of-age (BR: M=8.19 ±1.84; US: M= 8.87± 2.10) with an equal distribution of males and females for the two groups. The ethnic distribution for the Brazilian sample is as follows: white (66.5 %), African-Brazilian (7.6%), Asian –Brazilian (0.1%), other (7.7%), and did not report (18.1%). The distribution for the North American (US) sample is as follows: Caucasian (66.9 %), African-American (15.6 %), Asian–American (14%), and Hispanic (4.5%). The samples were comprised of children enrolled at university summer camps, local private and public local schools, and/or referred for assessment by parents, teachers, or clinicians. Children with a history or diagnosis of physical or intellectual disabilities were excluded. Children were assessed in quiet rooms located at the universities or at schools. Parents signed informed consent based upon the procedures respectively approved by the Federal University of Rio Grande do Sul or the University of Maryland’s Internal Review Board (IRB) at College Park; children provided informed assent.

*Instruments and procedures*

All children were individually assessed in a quiet room using the Movement Assessment Battery for Children - MABC by trained professionals with extensive previous experience. All professionals administering the MABC in the US and in Brazil underwent approximately 100 hours of training. The training included: study the battery’ manual and subtests, observe assessments, administer the MABC under supervision, and score children performance. All the professionals followed the same criteria to assess and score children performance provided in the MABC manual. Tasks were administered by demonstrations and instructions in the child’s respective language, English and Portuguese. Prior to the use of the battery for Brazilian children, a double-back reverse and independent translation procedure was conducted (tests, subtests and instructions) enrolling four professional (Hernandez-Nieto, 2002; Vallerand, 1989). Two independent translators, who have Portuguese as their native language, translated the MABC. After this first step, two translators, who have English as their native language, translate the Portuguese version to English. In a committee the translators and the main researcher, compared the English version with the original version of the MABC; revised the semantics of the Portuguese versions; and, unified the Portuguese version resulting in a final translated version of the battery in Portuguese.

The MABC assesses manual dexterity (MD), ball skills (BS), and balance (B). This version of the MABC was designed for children from 4- to 12-years-of-age. The MD and B subtests are comprised of 3 tasks, while the BS component is comprised of 2 tasks. The individual tasks within each test component differ by age band (AB) [AB1: 4 - 6 years old; AB2: 7 - 8 years old; AB3: 9 - 10 year old; AB4: 11-12 years old]; the difficulty of these tasks increase across the 4 age bands. Each item is scored on a scale from 0 to 5. The sum of the item scores of the tasks for each subtest provides a performance score of the child’s performance for that subtest (MD subtest score range from 0 to 15; BS subtest scores range from 0 to 10; B subtest scores range from 0 to 15). The sums of the 3 subtests compose the overall impairment score (IS) ranging from 0 and 40. Scores at or below the 5th percentile for the overall IS indicate severe motor coordination difficulties. In this manuscript, children classified in this category will be referred as “probableDCD” since the diagnosis of DCD requires the confirmation of movement difficulties by a mental health or medical professional (DSM-5, 2013). Confirmation of movement difficulties by a medical professional was not possible in the present study due to the large sample investigated. Scores between the 6th and 15th percentiles are considered indicative of “at-risk for DCD”; performance scores at or above the 16th percentile are considered indicative of no movement difficulties or in the range of typical development (TD) as established in the literature (Henderson & Sugden, 1992; Sugden et al., 2006).

The test-retest reliability (.64 to .97 for the age bands) and the inter-rater reliability (.70) have been reported for this version of the test (Henderson & Sugden, 1992). As mentioned, trained professionals administered the assessment. In the majority of the American sample, only one professional assessed the children. For Brazilian sample, two professionals assessed all the children. The inter-rater reliability coefficients were strong for the subscales (Manual Dexterity: α = .98; Ball skills: α = .92; Balance: α = .96). Since the MABC was not validated in Brazil, the internal consistency of the battery was assessed in the present sample. Examination of the Cronbach’s alpha coefficient suggested good reliability for the 3 subscales (MABC: α = .77) as well as for each subscale independently (MD α = .79; BS α = .73; B α = .83).

*Data analyses*

To address the first aim of the present study the prevalence of DCD was assessed for children from both countries. To address the second aim, ANOVA with Tukey’s post-hoc tests was conducted to examine the differences in subtests performance and impairment scores across the two countries with respect to the following factors: age band and sex. Multiple comparisons adjustments were conducted for the ANOVA using the Bonferroni procedure resulting in an adjusted value of *p* ≤ .008. To address the third and forth aims, a discriminant analysis was used, consistent with the methods outlined by Stevens (2009), to determine the discriminant function of the MABC in identifying children with probable DCD, at-risk for DCD, and TD in both countries and which of the three subtests of the MABC (MD, BS and B) could best predict group membership (probable DCD, at-risk for DCD and TD). Specifically, for the canonical analysis, a multiple group discriminant analysis automatically determined the overall discrimination between groups independently, that is, the contributions to the discrimination among groups did not overlap. The canonical analysis successive functions and canonical roots were used to determine group membership and MABC subtests predictive capacity.

**Results**

*DCD prevalence*

Our first objective was to explore differences in the prevalence of motor impairment across the samples from Brazil and the US by examining the percentages of probable DCD, at risk for DCD and TD as categorized by the MABC. Table 1 depicts the prevalence for Brazilian and North American samples by sex and age band. A higher prevalence of probable DCD and risk for DCD was found for Brazilian children. Brazilian girls and North American boys showed higher prevalence of probable DCD. Greater incidence of probable DCD was found at AB4 for the Brazilian sample. However, in the North American sample similar prevalence rates were found in the AB3 and AB4.

Insert Table 1 here

*Profile of Children with Motor Difficulties*

Our second aim was to examine age band and sex differences in MABC subtests for children across the two countries to determine differences in MABC scores. Table 2 presents MABC subtest means and standard deviations for the total sample by age band and sex. Tukey’s post hoc *p* values and significant results using the Bonferroni correction were also provided. Non-significant differences were observed between Brazilian and North American children with probable DCD and at-risk for DCD in total impairment score (IS) and MABC subtests. However, TD North American children showed significant lower IS (i.e., better overall performance) and better performance on the MD and BS subtests compared with TD Brazilian children.

Across all age bands no significant differences were found between North American and Brazilian children with probable DCD or at-risk for DCD for the MABC subtest and impairment scores. However, North American TD children showed significantly lower IS (i.e., better overall performance) compared with TD Brazilian children for AB1, AB2 and AB3; as well as better ball skills at AB2. No significant differences were found for AB4 for Brazilian and North American children.

Insert Table 2 here

Within-sex comparisons between countries revealed that Brazilian and North American girls with probable DCD and at-risk for DCD demonstrated similar performance; boys with probable DCD and at-risk for DCD were also similar across country (refers to table 2). In contrast, North American TD girls showed better performance in MD and lower impairment scores compared with TD Brazilian girls. North American TD boys showed superior ball skills and lower impairment scores compared to TD Brazilian boys. Taken together, these results revealed that differences between Brazilian and North American children appear restricted to typically developing children.

*MABC Discriminative ability*

The third aim was to examine the test’s ability to discriminate and predict motor impairment; and the forth aims was to identify the discriminating capacity of each subtest of the MABC. Table 3 presents the results from the discriminant analysis. The discriminant analysis yielded two functions. The first function accounted for more variability (Stevens, 2009) and provides the overall best discrimination among groups (probable DCD, at-risk for DCD, and TD) by age band and sex. All factors were significant for the total sample, when age band and sex were accounted for in the discriminant analyses (*p* < .0001).

The standardized canonical discriminate function coefficients showed that MD was the strongest discriminant factor (probable DCD, at-risk of DCD, TD) for Brazilian (r=. 85) and North American (r=.84) children. For the Brazilian children, the weakest discriminant factor was BS (r=.58), whereas for North American children was B (r=.60). With respect to age band, for the Brazilian sample the strongest predictor was MD across AB2 to AB4, with the only exception found in AB1, in which balance skills was a stronger predictor of DCD. For North American children, the results were more variable across age band. MD was the strongest predictor for AB2 and AB3 whereas B was identified for AB1 and AB4. In general, MD was the stronger predictor for both samples.

Insert Table 3 here

Table 4 provides the indices of success for the prediction rates of group membership from the discriminant analysis. The results showed no diffferences in scores. In both the Brazilian and North American samples the MABC scores showed strong predictive ability in identifing those at-risk for DCD, although this predictive power was lower in the classification of those with probable DCD. Moreover, the overall discriminant ability of the MABC was high for both countries (BR: 82.5 % and US: 87.7%).

Insert Table 4 here

Figure 1A and 1B illustrate relationships among the three groups (probable DCD, at-risk for DCD and TD) using two discriminant functions for both Brazilian and North American children. The group centroids for each variable in each discriminant canonical function are different for all the three groups (probable DCD, at-risk of DCD and TD) in both samples. The percentage of children in which the MABC scores were not capable of precisely predicting group membership were indicated via interpolation for both samples.

Insert Figure 1A and 1B here

**Discussion**

*DCD Prevalence*

Overall, the prevalence rates from the North American (US) sample (10.1 %) were consistent with the prevalence rates observed for Sweden **(Kadesjo & Gillberg, 1998)**,Canada (Tsiotra et al., 2006) and Colombia (Pineda, Lopera, Palacio & Ramirez, 2003). Brazilian prevalence in the current sample (24.1 %) was higher compared to these other countries but comparable results from a recent study of socially disadvantage Brazilian children (18% with probable DCD and 15% as at risk for DCD) (Valentini et al., 2014). The results from the Brazilian sample are also comparable to rates previously reported for Greek children (19%) (Tsiotra et al., 2006). Moreover, the prevalence of probable DCD was greater for Brazilian children from AB1 to AB4 compared to North American (US) children in these age bands.

One plausible explanation for the over-identification of DCD in the Brazilian sample could be related to the restricted opportunities in Brazil for children to develop gross and fine motor skills (Valentini, Clark & Whitall, 2014; Valentini et al, 2012). Specifically, in Brazil, public professional services and opportunities to attend early intervention programs are restricted (Valentini, Clark & Whitall, 2014: Spessato et al, 202). Therefore, delays in the achievement of motor milestones may go undetected in the early years of life. Furthermore, it is not mandatory for elementary physical education classes to be delivered by certified physical education teachers. All these factors combined may increases the chances of accumulation of motor delays throughout time. Yet, another possible explanation may the lack of psychometric investigation of the properties of the MABC. The accurate identification of motor impairments, as well as the generalization of tests outcomes (Vallerand, 1989) depends upon the use of reliable and valid instruments (Yun & Ulrich, 2002; Wiart & Darrah, 2001).

Across both samples, the results across age band showed a higher prevalence in older ages. For North American (US) and Brazilian samples, children in AB2 showed the smallest prevalence of probable DCD, whereas the prevalence increases at AB3 and AB4 for both samples, near 8% for North American (US) children and more than 100% for Brazilian children. These results suggest that older children failed to achieve age-appropriate skills. For AB3, children in both samples showed worse performance in manual dexterity. For AB4, we observed higher prevalence of probableDCD, which may be attributed to poor performance in manual dexterity for Brazilian children and poor performance in the balance for North American (US) children. The high DCD prevalence reported in the current study for AB3 and AB4 across both samples is alarming. Moreover, a similar trend is observed for children at-risk of DCD.

With respect to sex differences, the rates of DCD were greater for North American (US) boys compared to girls. This increased male incidence is often reported in the literature for several countries including: Canada (Missiuna et al., 2008), the Netherlands and Germany (Jongmans et al., 2003), and Sweden (Jucaite et al., 2003; **Kadesjo & Gillberg, 1998). For the Brazilian sample, higher prevalence rates were observed in girls,** consistent with those previous reports from Colombia (Pineda et al., 2003) and Brazil (Valentini et al., 2014). The high prevalence of DCD among girls in Latin America has been argued to be related to the limited access and reinforcement of girls’ participation in sport-related activities; and, also due to the greater assignment of girls to housework and family care (Valentini et al., 2004). All of these factors combined may limit motor development in Latina girls.

*Children’s Motor Profiles*

Among the three subtests, the performance of the Brazilian and North American (US) children with DCD was poorest for MD. It is well known that children with DCD perform poorly on tests that involve fine motor or manual dexterity skills (Summers et al., 2008); it is also likely that children in the at-risk for DCD group would also have difficulties with MD tasks. Fine motor skills are essential for the performance of playground activities, self-care, and school tasks. Difficulties in these skills alone provide a reason for referral for therapeutic interventions (Hartingsveldt & Oostendorp, 2005). In addition, for children in the at-risk group, difficulties with BS suggest that this area would also benefit from additional training.

Overall, there were no significant differences between the two countries for children with probable DCD and at-risk for DCD with respect to total impairment scores and subtest scores. These results provide support for the ability of the MABC to correctly classify children into the probable DCD and at-risk for DCD groups, regardless of differences in MABC scores. Given the ability of the MABC to discriminate the levels of motor skill impairment across samples, the present findings suggest that the MABC is an appropriate tool to evaluate fine and gross motor problems.

*MABC Discriminative Ability*

Across all subtests, MD was found to be the greatest discriminating factor for all groups of children (probable DCD, at-risk, and TD), supporting the notion that fine motor skills differentiate children with and without motor difficulties. Alternatively, these results could be interpreted to suggest that impairments in MD are key characteristics of DCD, regardless of any potential differences in the access to academic and extramural programs. Moreover, these difficulties in manual dexterity and fine motor skills may negatively impact school performance (DSM-5, 2013). Given that no significant differences were found between the two countries for the MD subtest, MD appears to be a sensitive predictor of overall motor difficulties. However, to date, the use of the MD subtest has not been considered a “gold standard” on its own (Hartingsveldt & Oostendorp, 2005). The only caveat to this conclusion is the finding that MD was not able to discriminate North American (US) children in AB4 into probable DCD, at-risk of DCD and TD groups. Despite this, the results from the present study suggest that MD tasks were more challenging for all children.

There are some discrepancies between the Brazilian and North American (US) samples regarding the discriminant ability of the other subtests. For example, the B subtest was second best for the Brazilian sample overall, while for the North American sample the B and BS subtests were ranked second depending on the sex and age-band. For example, although overall the BS subtest was a good predictor for children in AB1 and AB3 and for boys in across age band, it was a weaker predictor than B for children in AB2 and AB4 and girls across age band.

The discriminant validity was also confirmed by the significant difference among the groups (i.e., probable DCD, at-risk, and TD groups) (Breakweell et al., 2006). The MABC impairment scores, as well as the results from the individual subtests, were significantly different between children with probable DCD and those considered TD. Across all tasks, the performance of children with DCD was significantly lower than their TD peers. The results of the discriminant analysis and group comparisons showed that the two groups could be separated according to their performance on MD, BS, and B.

The categorization and discriminant accuracy of a test is an important characteristic from a psychometric perspective. The total impairment score of the MABC appeared to be most accurate in classifying children at-risk for DCD in Brazilian and North American samples (96.5% and 92.9% correct, respectively). TD children and children with probable DCD were also correctly identified using the MABC (Brazilian TD: 83.2%, North American TD: 88.9%, and Total DCD: 71.4%). Typically, assessments with classification accuracy above 90% are considered to have good discrimination, and those with 80%–89% are considered fair (Stevens, 2009). Based on these guidelines, the MABC was able to identify children at-risk for DCD with good discrimination and fair discrimination for those children considered probable DCD.

It is important to recognize that false positive classifications are inherent to developmental assessments (Stevens, 2009). The false positive rate was nearly 30% in both the Brazilian and North American (US) samples. In these instances, children at-risk for DCD were misclassified as DCD. This finding was somewhat unsurprising, given the large heterogeneity and range of motor difficulties demonstrated by those children in the lower end of the MABC performance continuum. However, these results suggest that for children classified into both the at-risk and DCD groups, follow-up assessments may be useful in further characterizing the nature of the motor difficulties, stability of these characteristics over time, and subsequent treatment options.

Of greater concern are the rates of false negatives, in which children were classified as at-risk but were actually in the probable DCD group. These rates were lower for the Brazilian sample (3.5%) compared with the North American (US) sample (7.1%). These results are cause for concern if the diagnosis of DCD was based solely on the MABC, as nearly 10% of the total sample of children with motor impairments would not receive the appropriate categorization of motor performance and the corresponding interventions. Thus, confirmatory assessments by a clinician or through parent or teacher reports may help to determine the extent of a child’s motor difficulties and isolate how the motor difficulties impede activities of daily living.

**Conclusion**

The study demonstrated high discriminant and predictive ability of the MABC across Brazilian and North American (US) children 4- to 12-years-of-age. In general, the MD subtest was found to be the greatest predictor of classification into the TD, at-risk, and probable DCD groups for all children, except 11- to 12-year-old North Americans. The DSM-5 requirement of the confirmation of movement difficulties by a mental health or medical professional was a limitation of the present study. Additional potential common comorbidities, such as Autism Spectrum Disorder and Attention Deficit Hyperactivity Disorder, were not examined in the current study; the parents or health professionals may provide this information. Moreover, differences in body composition, which may affect motor performance (Cairney, Hay, Faught& Hawes, 2005), were also not examined in the present study. Despite these limitations, the current study provides additional and important evidence regarding the psychometric properties of MABC first edition. The outcomes of the present study suggest that the MABC is a valid and appropriate screening instrument for movement difficulties in the clinical and education settings in Brazil and US.

**Key points**

1. Our study demonstrated the high discriminant and predictive ability of the MABC across Brazilian and North American (US) children covering a large sample and age range.
2. For the majority of children, the Manual Dexterity subtest was found to be the greatest predictor of classification into the typical development, at-risk, and probable DCD groups.
3. The study added to current knowledge demonstrating that regardless of countries possible distinctions in school experience and opportunities, there were no significant differences between the two countries for children with probable DCD and at-risk for DCD with respect to total impairment scores and subtest performance.
4. Differences in performance were only observed for children with typical development and only in two subtests of MABC, manual dexterity for girls and ball skills for boys, with advantage in scores for North American (US) children.
5. Our findings support the ability of the MABC to correctly classify children into the probable DCD and at-risk for DCD groups.
6. The outcomes of the present study highlighted the MABC as a valid and appropriate tool to evaluate fine and gross motor difficulties.

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Table 1. Brazilian and North American prevalence of probable DCD, at-risk for DCD and TD by Age Band and Sex

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Total sample  AB & Sex | | N (%) | | | | | |
| Probable DCD | | At-Risk DCD | | TD | |
| BR | US | BR | US | BR | US |
| Total | Total | 168(24.1) | 36(10.1) | 113(16.2) | 42(11.7) | 417(59.7) | 280(78.2) |
|  | Girls | 91(26.1) | 14(7.8) | 57(16.3) | 23(12.8) | 201(57.6) | 142(79.3) |
|  | Boys | 77(22.1) | 22(12.3) | 56(16) | 19(10.6) | 216(61.9) | 138(77.1) |
| AB1 | Total | 26(17.4) | 6(7.5) | 30(20.1) | 10(12.5) | 93(62.4) | 64(80) |
|  | Girls | 12(16.2) | 4(10) | 15(20.3) | 7(17.5) | 47(63.5) | 29(72.5) |
|  | Boys | 14(18.7) | 2(5) | 15(20) | 3(7.5) | 46(61.3) | 35(87.5) |
| AB 2 | Total | 27(14.6) | 6(6.4) | 20(10.8) | 6(6.4) | 138(74.6) | 82(87.2) |
|  | Girls | 16(17.2) | None | 12(12.9) | 2(4.3) | 65(69.9) | 45(95.7) |
|  | Boys | 11(12) | 6(12.8) | 8(8.7) | 4(8.5) | 73(79.3) | 37(78.7) |
| AB 3 | Total | 88(27.8) | 21(13) | 55(17.4) | 24(14.8) | 173(54.7) | 117(72.2) |
|  | Girls | 49(31) | 9(11.1) | 26(16.5) | 13(16) | 83(52.5) | 59(72.8) |
|  | Boys | 39(24.7) | 12(14.8) | 29(18.4) | 11(13.6) | 90(57) | 58(71.6) |
| AB 4 | Total | 27(56.3) | 3(13.6) | 8(16.7) | 2(9.1) | 13(27.1) | 17(77.3) |
|  | Girls | 14(58.3) | 1(9.1) | 4(16.7) | 1(9.1) | 6(25) | 11(81.8) |
|  | Boys | 13(54.2) | 2(18.2) | 4(16.7) | 1(9.1) | 7(29.2) | 8(72.7) |

Note. Developmental Coordination Disorder (DCD); TD: typical development

Table 2. MABC scores for Brazilian & North American (US) samples: Age Band and Sex

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total &  Age Band | | M(SD) & *p* values | | | | | | | | |
| Probable DCD | | | At-risk DCD | | | TD | | |
| BR | US | *p* | BR | US | *p* | BR | US | *p* |
| Total | MD | 8.7(3.4) | 8.5(3.2) | .76 | 5.7(2.7) | 5(2.7) | .11 | 2.5(2.3) | 1.8(1.9) | .0001\* |
|  | BS | 4.3(2.9) | 4.1(2.5) | .72 | 2.7(2.4) | 3.4(2.3) | .09 | 1.6(1.8) | 1.1(1.6) | .001\* |
|  | B | 5.4(3.4) | 5(3.6) | .52 | 3.3(2.1) | 3.1(2.6) | .61 | 1.3(1.5) | 1(1.5) | .01 |
|  | IS | 19.1(8) | 17.6(5) | .28 | 11.7(1.4) | 11.5(1.3) | .41 | 5.4(2.9) | 4(2.6) | .0001\* |
| AB1 | MD | 6.7(4) | 7.3(1.9) | .72 | 5(2.6) | 4.4(2.7) | .53 | 2.1(2) | 1.6(1.8) | .09 |
| BS | 5.3(3.1) | 6.3(2.4) | .44 | 3.2(2.3) | 3.4(1.5) | .80 | 1.9(1.9) | 1.3(1.7) | .04 |
| B | 7(4.8) | 2.6(2.4) | .06 | 4.2(2.3) | 4.3(2.6) | .88 | 1.6(1.9) | 1.2(2) | .16 |
|  | IS | 24(16.7) | 17(3.9) | .30 | 12.4(1.9) | 12.2(1.6) | .08 | 5.7(3.2) | 4.1(2.9) | .002\* |
| AB2 | MD | 7.9(3) | 7.3(1.2) | .66 | 4.6(3.1) | 5.3(1.9) | .58 | 2.2(2.2) | 1.7(1.9) | .07 |
| BS | 4.9(2.9) | 3.9(2.3) | .44 | 4.2(2.3) | 4.8(1.6) | .57 | 2.2(1.9) | 1.4(1.7) | .003\* |
| B | 3.9(3) | 4.7(3) | .53 | 2.3(1.7) | 1.1(.7) | .11 | .6(1) | .5(.9) | .36 |
|  | IS | 16.1(4.1) | 16(3.4) | .94 | 11.1(.95) | 11.2(1) | .74 | 5.0(3) | 3(.6) | .0001\* |
| AB3 | MD | 9.2(3.2) | 9.2(3.4) | .99 | 6.3(2.4) | 5.4(2.8) | .12 | 2.9(2.4) | 2.1(2.2) | .004 |
| BS | 4.1(3) | 3.4(2.4) | .26 | 2.1(2.3) | 3.3(2.7) | .06 | 1(1.6) | .8(1.4) | .25 |
| B | 5.3(2.8) | 4.8(3.1) | .44 | 3.1(1.9) | 2.6(2.2) | .26 | 1.7(1.5) | 1.2(1.5) | .012 |
|  | IS | 18.7(17) | 17(3.6) | .20 | 11.6(1.2) | 11.2(1.1) | .22 | 5.6(2.8) | 4.1(2.6) | .0001\* |
| AB4 | MD | 10(3) | 8.8(5.8) | .57 | 7.1(2.6) | 1.5(0) | .02 | 3.7(2.6) | 1.6(1.8) | .01 |
| BS | 2.8(2.2) | 4.7(2.5) | .18 | .9(1.2) | 1.5(0) | .51 | 1.1(1.6) | 1.5(1.6) | .51 |
| B | 5.7(3.2) | 11(3.6) | .01 | 3.2(2.6) | 8.5(2.1) | .03 | 1.4(1.3) | 1.3(1.8) | .88 |
|  | IS | 18.6(4) | 24.5(10) | .05 | 11.2(.80) | 11.5(2.1) | .77 | 6.2(2.8) | 4.4(2.7) | .08 |
| Girls | MD | 8.3(3.2) | 7.5(3.4) | .36 | 5.4(2.8) | 3.8(2.6) | .02 | 2.1(2.2) | 1.4(1.6) | .001\* |
|  | BS | 5(2.6) | 4.3(2.2) | .37 | 3.2(2.4) | 4.4(2) | .03 | 2(1.9) | 1.6(1.7) | .04 |
|  | B | 5(3) | 4.9(3.1) | .89 | 3(2.1) | 3.1(2.8) | 84 | 1.2(1.6) | .8(1.50 | .05 |
|  | IS | 18(4.4) | 16.7(3.6) | .23 | 11.6(1.4) | 11.5(1.2) | .60 | 5.4(3) | 3.9(2.5) | .0001\* |
| Boys | MD | 9.2(3.6) | 9.2(2.9) | .10 | 6.1(2.6) | 6.3(2) | .69 | 2.8(2.3) | 2.2(2.2) | .02 |
|  | BS | 3.3(3) | 3.9(2.8) | .46 | 2.2(2.4) | 2.2(2) | .93 | 1.2(1.7) | .6(1.3) | .001\* |
|  | B | 5.8(3.7) | 5(3.9) | .40 | 3.5(2.1) | 2.9(2.5) | .35 | 1.4(1.5) | 1.1(1.6) | .18 |
|  | IS | 20(11) | 18(5.3) | .40 | 11.7(1.5) | 11.5(1.4) | .53 | 5.5(2.9) | 4(2.8) | .0001\* |

Note. M: Mean: SD: Standard Deviation; MD: manual dexterity; BS: ball skills; B: balance; IS: impairment score: Developmental Coordination Disorder (DCD); \* significant results with Bonferroni correction (p ≤ 0.008)

Table 3. Standardized coefficients for canonical discriminant function 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Factors | BR | | | | | | | US | | | | | | | |
| Total | Age Bands | | | | Sex | | Total | Age Bands | | | | Sex | | |
|  | 1 | 2 | 3 | 4 | Girls | Boys |  | 1 | 2 | 3 | 4 | | Girls | Boys | |
| MD | .85 | .56 | .85 | .89 | .98 | .87 | .83 | .84 | .76 | .68 | .96 | .02 | | .84 | .81 | |
| BS | .58 | .55 | .60 | .63 | .43 | .69 | .40 | .68 | .80 | .57 | .73 | .30 | | .69 | .62 | |
| B | .62 | .68 | .63 | .59 | .79 | .62 | .65 | .60 | .48 | .68 | .63 | .95 | | .72 | .50 | |

Note: BR: Brazil; US: United States of America

Table 4. Success rates for the prediction of group membership for the discriminant functions

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Classification | | BR | | | US | | |
| Predict Group Membership | | | Predict Group Membership | | |
| Probable DCD | At-risk DCD | TD | Probable DCD | At-risk DCD | TD |
| % | Probable DCD | 71.4% | 26.8% | 1.8 | 71.4 | 28.6 | 0 |
| At-Risk DCD | 3.5% | 96.5% | 0 | 7.1 | 92.9 | 0 |
| TD | .5% | 16.3% | 83.2 | 0 | 11.1 | 88.9 |
| % | MABC | 82.5% of original data correctly classified | | | 87.7% of original data correctly classified | | |

Note: BR: Brazil; US: United States of America; TD: typical development; DCD: Developmental Coordination Disorder

Figure 1A and 1B. Canonical discriminant functions and the group centroids for Brazilian and North American (US) probable DCD, at-risk for DCD, and TD children.

