The concurrent validity of the Developmental Coordination Disorder Questionnaire (DCDQ) and the McCarron Assessment of Neuromuscular Development (MAND) was investigated in an Australian sample of 38 girls and 91 boys aged 9–12 years ($M = 11.15, SD = 0.81$). The MAND identified 44 children with motor impairment (MI) and 85 children without MI. The overall decision agreement between the two measures in identifying MI was .64. The DCDQ had a sensitivity of .55 and a specificity of .74. The DCDQ was accurate in identifying children with moderate or severe MI but identified less than half of the children with mild MI.

Children identified with Developmental Coordination Disorder (DCD) have a marked impairment in their motor coordination that cannot be explained by the child’s age and intellect or by any neurological or psychiatric condition (APA, 2000). The disorder has a prevalence rate of about 6% (APA, 2000), although identification is made difficult due to the presence of different subtypes with a wide range of motor problems (Dewey & Kaplan, 1994; Hoare, 1994; Miyahara, 1994). Children with DCD not only experience motor difficulties per se (Cermak, Gubbay, & Larkin, 2002) but also need to deal with a series of psychosocial, emotional, and academic issues (Cantell, Smyth, & Ahonen, 1994; Dewey, Kaplan, Crawford, & Wilson, 2002; Gillberg & Gillberg, 1989; Skinner & Piek, 2001). It is therefore imperative to identify these children early. This allows interventions targeted at addressing the motor difficulties and its associated problems to be rendered to minimize the negative long-term outcomes (Cratty, 1994; Jongmans, 2005; Skinner & Piek, 2001).

Motor difficulties are often seen in children with Attention Deficit Hyperactivity Disorder (ADHD; Fox & Lent, 1996; Kadesjo & Gillberg, 1998; Landgren, Pettersson, Kjellman, & Gillberg, 1996; Piek, Pitcher, & Hay, 1999; Pitcher, Piek, & Hay, 2003) but these problems have been attributed to inattention and distractibility (APA, 1994). It is therefore important to differentiate motor difficulties occurring as a result of DCD and not due to the symptoms of other disorders such as ADHD.
Population screening can be an effective way of identifying children at risk for DCD. It is a quick and simple method of examining a large population of individuals in search of those who may exhibit the problem. These children should then be referred for a detailed motor assessment (Jongmans, 2005). Currently, norm-referenced motor tests are generally used to identify children with DCD (Piek, 2006). This method is time consuming and cost ineffective for population screening.

A number of screening checklists have been developed to help identify children with DCD. Besides identifying motor impairments, they provide a good source of background information on the child’s activities of daily living and social difficulties arising from the motor impairments that cannot be elicited from norm-reference motor tests (Larkin & Rose, 2005). The screening results can also be compared with known diagnostic findings, either obtained concurrently or at a later time (Kaplan, Wilson, Dewey, & Crawford, 1998; Maeland, 1992; Riggen, Ulrich, & Ozmun, 1990). The success of such checklists, however, depends on their ability to differentiate poor from normal motor coordination in these children. Methodologically, this can be established by comparing the test result against a known “gold” standard criterion that determines the presence or absence of a target condition (Portney & Watkins, 2000). A major issue for DCD research is that there is no such “gold” standard for assessment of motor skills. Moreover, there is no universally agreed level of motor dysfunction that determines a diagnosis of DCD (Dewey et al., 2002). Nevertheless, the ICD-10 (WHO, 1993) advocates the presence of motor impairment (MI) when the child’s score on a standardized motor test is 2 standard deviations below the reference norm. A cut-off score at the 15th percentile on the motor tests is recommended for research purposes to prevent excluding children with mild DCD (Geuze, Jongmans, Schoemaker, & Smits-Engelsman, 2001).

Taking all the above into consideration, the current study examined the accuracy of a screening test, the Developmental Coordination Disorder Questionnaire (DCDQ), in identifying children with MI in a sample of children where a high proportion of them have a comorbid ADHD condition. The DCDQ was chosen due to its limited exposure on Australian children. The McCarron Assessment of Neuromuscular Development (MAND) was used as a criterion measure against which the DCDQ was assessed.

The DCDQ is a parent-rated questionnaire (Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000). The questionnaire was developed using a Canadian population of clinic-referred children between eight and fourteen years of age, of which two-thirds experienced learning or attention disorders. Globally, the use of the DCDQ has not been widespread and validation studies on its usefulness with different populations of children have been limited. From the European continent, Green et al. (2005) and Schoemaker et al. (2003, cited in Green et al., 2005) are the only two reported studies on the validity of the DCDQ on children. Within Australia, the use of the DCDQ is not common. Martin, Piek, and Hay (2006) and Piek et al. (2007) are the only identified research papers to have made use of the DCDQ for identifying children with DCD. There are no known studies that have examined the reliability and validity of the DCDQ in the Australian population.

The MAND, published in 1982, was designed as a screening, evaluation, and research tool for clinicians, therapists, educators, and researchers (McCarron,
Loh, Piek, and Barrett (1997). Geuze et al. (2001) reported that it is one of the most commonly used motor tests for the identification of children with MI in research studies. This test is also currently used for clinical screening in several developmental motor skills programs in Australia (Tan, Parker, & Larkin, 2001). More importantly, this measure has had more exposure in the research literature that has used Australian samples (e.g., Dyck et al., 2004; Hoare, 1994; Piek et al., 2004). Tan et al. (2001) reported that the MAND is a more accurate discriminator of MI, with higher sensitivity and negative predictive values than the Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOTMP-Short Form; Bruininks, 1978). Hence, the MAND is considered to be a more valid test for identifying MI in Australian children (Tan et al., 2001).

The DCDQ is a potentially useful screening test for identifying MI in children. Wilson et al. (2000) compared the DCDQ with the BOTMP (Bruininks, 1978) and the Movement Assessment Battery for Children (MABC; Henderson & Sugden, 1992). Although the DCDQ was significantly correlated with both tests, it was more highly correlated with the MABC, probably since the DCDQ and MABC were designed to identify motor problems whereas the BOTMP assesses motor skills intended for educational placement and programming. On the other hand, Green et al. (2005) reported a low overall agreement (kappa = 0.14) between DCDQ and an occupational therapy assessment, which included a variety of motor, visual motor, cognitive, and performance measures. The sensitivity and the predictive values of the DCDQ, however, were high. These authors attributed the low agreement between tests to their skewed sample, which was made up of a high proportion of children with DCD compared with children without DCD. In addition, these authors found a significant difference in the DCDQ total score between children with and without a second diagnosis. This result led them to suggest that the presence of a coexisting condition in children with DCD could have a confounding influence on the DCDQ, thus reducing its reliability. Many children whose parents overidentified their coordination difficulties were found to have additional conditions, which may have explained the child’s functional difficulties (Green et al., 2005).

Hence, in examining the accuracy of the DCDQ, the current study sought to assess the concurrent validity of the DCDQ and the MAND. A strong positive correlation and a high case agreement between the scores on the DCDQ and MAND would indicate that both tests were measuring the same construct. Next, the discrimination and predictive accuracy of DCDQ was determined. Discrimination is evaluated from the test’s sensitivity and specificity according to Portney and Watkins (2000). Sensitivity is defined as the test’s ability to accurately identify the target condition when it is really present. Specificity is defined as the test’s ability to accurately identify the absence of the target condition when it is really absent. The test’s predictive value provides an indication of the usefulness of the DCDQ as a clinical screening tool. The test was evaluated for efficiency in terms of time and resources and also for whether it yields a sufficient number of accurate responses to be clinically useful (Portney & Watkins, 2000). To be clinically useful, the test must therefore display both positive predictive value (a person who is positively tested for the target condition actually has the condition) and negative predictive value (a person who is negatively tested for the target condition does not have the condition).
The influence of ADHD on the accuracy of the DCDQ in identifying MI in children with and without ADHD symptoms was also examined. It was expected that if the DCDQ was measuring solely motor performance, there should be no significant group difference in the DCDQ scores between children with and without ADHD. The DCDQ scores for children with MI were also not expected to be significantly different from children with ADHD and MI; however, a significant difference in DCDQ scores was expected between children with MI and those without, regardless of the presence of ADHD symptoms.

In essence, if a test is more sensitive, positive cases are more readily identified and many true cases will not be missed. A more specific test will result in negative cases being more readily identified, thus eliminating false positive cases. Therefore, if a high case agreement between the DCDQ and MAND is obtained, together with high sensitivity and specificity and good predictive values for the DCDQ, these findings would provide empirical evidence for the use of DCDQ as a valid screening tool for identifying MI in Australian children.

**Method**

**Participants**

Participants for this study were obtained from a larger project examining the motor difficulties in children with ADHD and DCD. Scores on the MAND and the DCDQ were obtained from a total of 129 children. Of these, 124 were recruited from primary schools (state and private) and five recruited through advertisement (also attended state schools). All children were from the metropolitan area of Perth. There were 38 girls and 91 boys, and their ages ranged from 9.62 years to 12.75 years ($M = 11.15$, $SD = 0.81$). All children had normal or corrected vision and normal hearing. Children with serious postnatal complications, permanent head injury, neurological disorder, and physical disability were excluded. All except 19 participants were right-handed. Of the 129, 97 children were not diagnosed with any childhood disorder. Of the 32 children with a previously diagnosed single or comorbid childhood disorders, 11 were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD), six children with motor problems (including poor fine and/or gross motor skills, dyspraxia and hypotonia), one child with ADHD and motor problems, seven children with Learning Disorder (LD), one child with LD and motor problems, four children had ADHD and LD, and two children had ADHD, LD, and motor problems. Of the 18 children diagnosed with ADHD with or without comorbidity, 16 of them were currently on stimulant medication. All except one in the ADHD group abstained from stimulant medication during the testing. Information pertaining to the above was obtained through the screening questionnaire filled in by parents.

**Measures**

**Developmental Coordination Disorder Questionnaire.** The Developmental Coordination Disorder Questionnaire (DCDQ; Wilson et al., 2000) was developed for children between the ages of 8 and 14.5 years. It is a 17-item parent-report questionnaire. Each item is scored on a scale of 1–5 ranging from *not at all like*
my child to extremely like my child with an overall score of 85. The DCDQ total score that falls within the range of 0–48 (0–10th percentile) indicates probable DCD, 49–57 (11–25th percentile) indicates suspected DCD, and 58–85 (26–100th percentile) indicates probably not DCD. The DCDQ has four subscale factors, namely control during movement, fine/handwriting, gross motor/planning, and general coordination. The DCDQ has an internal consistency alpha coefficient of 0.88 and item-total correlations ranging from $r = 0.40$ to $r = 0.76$. Its concurrent validity with the MABC (Henderson & Sugden, 1992) and the BOTMP (Bruininks, 1978) were 0.46 and 0.54, respectively. The questionnaire was reported to correctly classify 86% of children with DCD and 71% of children without DCD (Wilson et al., 2000).

McCarron Assessment of Neuromuscular Development. The McCarron Assessment of Neuromuscular Development (MAND; McCarron, 1997) measures the full range of motor abilities in children ranging from age 3.5–18 years. It comprises ten tasks, with five measuring fine motor skills (putting beads in a box, putting beads on a rod, finger tapping, putting a nut on a bolt, and moving washers along a rod) and five measuring gross motor skills (touching the nose and the finger of opposite extended arm, jumping, heel to toe walking, standing on one foot, and hand strength). A Neuromuscular Developmental Index (NDI) is derived from the summation of the age-norm scaled scores on each task. The MAND also provides four subscale factors: “Persistence Control”—a measure of controlled eye-hand coordination; “Muscle Power”—a measure of coordinating the simultaneous contraction of muscle units; “Kinaesthetic Integration”—a measure of control of balance and body orientation in space; and “Bimanual Dexterity”—a measure of two-hand coordination. Both the NDI and the four factor scores have a mean of 100 and a standard deviation of 15. The cut off score indicating MI is at the 15th percentile and the range is classified as follows: 71–85 a mild disability, 55–70 a moderate disability, and those below 55 as having a severe disability. The test-retest reliabilities of the ten tasks after a month interval were found to range from 0.67 to 0.98. In addition, the MAND has a high predictive validity of $r = 0.70$ in a mentally disabled adult population (McCarron, 1997).

Australian Disruptive Behaviors Scale. The full form of the Australian Disruptive Behaviors Scale (ADBS) is a parent-report questionnaire that fulfil the DSM-IV (APA, 1994) criteria for ADHD, oppositional defiant disorder, conduct disorder, and separation anxiety (Levy & Hay, 1991). This rating scale was originally designed for the Australian Twin ADHD Project (ATAP) and the shortened form identifying only the ADHD symptoms was employed in the current study. This scale has been employed in other studies (e.g., Levy, Hay, McLaughlin, Wood, & Waldman, 1996; Levy, Hay, McStephen, Wood, & Waldman, 1997; Levy, Hay, Bennett, & McStephen, 2005; Martin et al., 2006; Piek et al., 1999). It consists of eighteen ADHD items, with nine inattentive symptoms and nine hyperactive-impulsive symptoms. Examples of these items included “Is easily distracted by things happening around him/her” (e.g., noise or people talking), “Has difficulty keeping attention on work or games,” “Fidgets with hands or feet or squirms in seat,” and “Has difficulty awaiting his/her turn.” The rater is directed by a standard set of instructions to indicate the applicability of each item for the child at present
or within the last six months with a scale of 0 (not at all), 1 (just a little/sometime), 2 (pretty much/often) and 3 (very much/very often). Rating of 0 or 1 indicates absence of symptom whereas rating of 2 or 3 indicates symptom present. ADHD-PI categorical group membership requires at least six inattentive symptoms but fewer than six of the hyperactive-impulsive symptoms. ADHD-HI group membership should have at least six of the hyperactive-impulsive symptoms but less than six of the inattentive symptoms. ADHD-C group membership required at least six symptoms from each of the two sets of symptoms.

Parental rating of ADBS has shown that it is a conservative indicator of symptom presence (Levy et al., 1996). This measure has been found to be a valid method of identifying subtypes of ADHD in children with internal consistency coefficients of 0.93 and 0.95 for identifying the presence of inattentive symptoms and hyperactive/impulsive symptoms, respectively (Levy & Hay, 2001). Furthermore, this method of establishing ADHD symptoms is consistent with the procedures used in other studies (e.g., Martin et al., 2006; Pelham, Gnagy, Greenslade, & Milich, 1992; Pitcher, Piek, & Barrett, 2002; Pitcher et al., 2003).

**Group Allocation**

Assessment of MI in children was based on the NDI score of the MAND. Children who had an NDI score of ≤85 (a cut-off score at the 15th percentile) on the MAND were identified as having MI. Children who had an NDI score of >85 on the MAND were considered as no MI. This resulted in 44 children (10 girls and 34 boys) being identified as having MI. On the DCDQ, children who scored below the 25th percentile were identified as having MI. This method is consistent with the classification method used in Green et al.’s (2005) study. Based on this cut off, 46 children (11 girls and 35 boys) were identified as having MI by the DCDQ. In the current study, children identified as having MI were placed in the MI group, while children identified as not having MI were placed in the non-MI group. Children were also assessed for ADHD symptoms, based on the scores on the Australian Disruptive Behaviors Scale (ADBS). If the child had six or more symptoms on either one or both dimensions on the ADBS, this child was placed in the ADHD group. The non-ADHD group comprised children who scored less than 6 symptoms on both dimensions on the ADBS. The ADBS was used to create an ADHD group that is closely aligned to the DSM-IV ADHD diagnosis. Based on this questionnaire, nine girls and 45 boys (including children that had been previously diagnosed by their clinicians) formed the ADHD group.

**Procedure**

Participants were treated in accordance with the ethical guidelines outlined by the National Health and Medical Research Council of Australia. Ethics approval was obtained from Curtin University on all protocols including obtaining written consent from the parents. Recruitment was targeted at children with and without MI or ADHD symptoms. The children were recruited via two routes, either through the 33 participating primary schools or through public advertisement via the Learning and Attentional Disorder Society (LADS), community newspapers in metropolitan Perth, and the Curtin FM radio station.
Selection of schools was from a larger randomly selected sample of 135 schools that were invited to participate. The larger sample of schools was located within a 30 km radius of Curtin University. A total of 4,640 recruitment letters containing the participant information sheet, parent/guardian consent form, and a reply-paid envelope were distributed to students between the ages of 10 and 12 years from the consenting schools. From this, 124 children were recruited. For public recruitment, nine interested parents contacted the researcher and the recruitment letters were sent to them. Of these, five parents gave their consent for their child to participate. Upon receiving the consent form from the parents, the ADBS, DCDQ, initial screening questionnaire (detailing any medical history and physical condition of the child), and a reply-paid envelop were sent to parents of the participating child. The response rate for returning the questionnaires was 100%.

The administration of the MAND was conducted either in the child’s school or at Curtin University. The testing time was 30–40 min per child. All children were tested individually in a quiet room by one of the three testers trained in the administration of the MAND.

**Data Analysis**

The concurrent validity between the MAND and DCDQ was examined by (a) conducting a Spearman rank order correlation on the NDI score, the DCDQ total score and on the four factors scores from each measure and (b) determining the case agreement between the MAND and DCDQ by calculating the percentage of cases in the MI and non-MI groups identified by the MAND and the DCDQ. The discrimination accuracy of the DCDQ was inferred from its sensitivity, specificity, and the positive and negative predictive values according to the formula recommended by Portney and Watkins (2000).

In examining the influence of ADHD on the DCDQ, the children were reorganized into four groups based on the MAND and the ADBS: the comparison group for children with no MI or ADHD symptoms, the MI group for those with MI; the ADHD group for those having ADHD symptoms, and the ADHD/MI group for those with ADHD and MI symptoms. A one-way ANOVA was performed on the DCDQ total scores for these four groups.

**Results**

**Descriptive data**

Table 1 gives the means and standard deviations for the DCDQ and MAND scores for children identified with and without MI.

The MAND identified 30 children having mild MI (NDI 71–85), nine children having moderate MI (NDI 55–70), and five children with severe MI (NDI < 55). From these three groups identified by the MAND, the DCDQ identified 12 children in the mild group, eight children in the moderate group, and all five children in the severe group as having MI.
<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>MI</th>
<th>non-MI</th>
<th>MI</th>
<th>non-MI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n)</td>
<td></td>
<td>10</td>
<td>28</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>10.94</td>
<td>77</td>
<td>98</td>
<td>50</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>0.87</td>
<td>11</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n)</td>
<td></td>
<td>34</td>
<td>57</td>
<td>35</td>
<td>56</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>11.24</td>
<td>73</td>
<td>106</td>
<td>48</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>0.77</td>
<td>11</td>
<td>13</td>
<td>8</td>
</tr>
</tbody>
</table>
Relationship Between MAND and DCDQ

A Spearman rank order correlation was conducted on the total scores and the factors scores of the two measures. The correlation between the NDI score and the DCDQ total score was statistically significant, $r_s (127) = 0.37, p = 0.01$. The common variance shared by the two measures was only 14%, indicating a low association between them. The correlation coefficients for the factors scores between measures were also statistically significantly low. Table 2 provides the Spearman’s correlation coefficients between the factors scores of the MAND and the DCDQ.

Case Agreement

The degree of concurrent validity indexed by case agreements between the DCDQ and MAND is shown in Table 3. As indexed by Cohen’s Kappa, the degree of agreement between the two measures was low (kappa $= 0.284$). Of the 129 cases, the DCDQ identified 46 cases as having MI (probable or suspect) while the MAND identified 44 cases as having MI. The decision agreement analysis showed that both tests identified the same 24 cases with MI and the same 63 cases without MI; however, the remaining 44 cases were mismatched. Twenty cases were identified as having MI by the MAND but the DCDQ scores indicated no motor difficulties. Further, the DCDQ identified 22 cases as having MI but their NDI scores were within the normal range. Therefore, the overall decision agreement between the two tests was 67.4% $[((24+63)/129) \times 100]$ with a proportion of agreement of 0.55 for cases identified as having MI.

Table 2  Spearman’s Correlation Coefficients Between the Factors Scores From the MAND and the DCDQ

<table>
<thead>
<tr>
<th></th>
<th>MAND</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Persistent control</td>
<td>Muscle power</td>
<td>Kinesthetic integration</td>
<td>Bimanual dexterity</td>
</tr>
<tr>
<td>DCDQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control during movement</td>
<td>0.222**</td>
<td>0.321**</td>
<td>0.329**</td>
<td>-.015</td>
</tr>
<tr>
<td>Fine/handwriting</td>
<td>0.201**</td>
<td>-.059</td>
<td>0.255**</td>
<td>0.174*</td>
</tr>
<tr>
<td>Gross motor/ planning</td>
<td>0.186*</td>
<td>0.258**</td>
<td>0.229**</td>
<td>0.010</td>
</tr>
<tr>
<td>General coordination</td>
<td>0.277**</td>
<td>0.095</td>
<td>0.255**</td>
<td>0.268**</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (one-tailed).
* Correlation is significant at the 0.05 level (one-tailed).
The number of cases identified in the MI and non-MI groups by the DCDQ and MAND (NDI ≤ 85) are displayed in Table 3. The sensitivity of the DCDQ in identifying MI was 55% \[a/(a+c)\] (a = true positive, c = false negative), whereas its specificity for identifying the absence of MI was 74% \[d/(b+d)\] (b = false positive, d = true negative). The positive predictive value of DCDQ was 52% \[a/(a+b)\], indicating that only half of the total cases identified as MI actually had MI according to the MAND. The DCDQ had a negative predictive value of 76% \[d/(c+d)\], indicating that 24% of the cases identified as having no MI did have MI according to the MAND score. Overall, the discrimination accuracy of the DCDQ was low.

**Discrimination Accuracy**

The number of cases identified in the MI and non-MI groups by the DCDQ and MAND (NDI ≤ 85) are displayed in Table 3. The sensitivity of the DCDQ in identifying MI was 55% \[a/(a+c)\] (a = true positive, c = false negative), whereas its specificity for identifying the absence of MI was 74% \[d/(b+d)\] (b = false positive, d = true negative). The positive predictive value of DCDQ was 52% \[a/(a+b)\], indicating that only half of the total cases identified as MI actually had MI according to the MAND. The DCDQ had a negative predictive value of 76% \[d/(c+d)\], indicating that 24% of the cases identified as having no MI did have MI according to the MAND score. Overall, the discrimination accuracy of the DCDQ was low.

**ADHD Influence on the DCDQ**

Of the 54 children in the ADHD group, the MAND identified 30 children with no MI. From these 30 children, the DCDQ identified 16 children as having MI. To examine if the classification of ADHD was related to scores on the DCDQ, a one-way ANOVA was conducted to examine group differences on the DCDQ total scores for the comparison, ADHD, MI, and ADHD/MI groups. The result revealed a statistically significant group difference, \[F(3, 125) = 17.17, p = 0.001\]. Planned comparisons showed that the comparison group differed statistically significantly from the other three groups; however, there was no statistically significant difference in the DCDQ score between the latter three groups. The children in the comparison group obtained a statistically significantly higher DCDQ score than children in the ADHD, MI, and ADHD/MI groups. The mean DCDQ total scores for all four groups are provided in Table 4.
The ability of the DCDQ to identify motor impairment in children in an Australian sample was examined using the MAND as the criterion measure. A low association between the DCDQ and the MAND was found in this study, indicating that the two measures largely assess different aspects of motor performance in the children. The overall decision agreement between DCDQ and MAND (67.4%) fails to meet the 80% satisfactory level for concurrent validity recommended by Riggen et al. (1990). This low overall agreement, however, is consistent with that reported in the European sample (kappa = .14; Green et al., 2005). In addition, the DCDQ was found to have low discrimination accuracy. The overall results obtained in this study suggest that the DCDQ as a screening tool is not highly proficient in discriminating children with MI from those without.

It has been pointed out that different motor tests used to identify children with DCD produce different samples of children (Larkin & Cermak, 2002). This situation, in part, reflects the heterogeneous nature of the motor problems in children with DCD. Motor tests designed to tap only a particular aspect of the motor function may fail to identify children with other forms of motor difficulties. On the other hand, the situation also reflects the characteristics of the population used to standardize the motor tests (Piek, 2006).

The findings of a low association between the MAND and the DCDQ, and the poor sensitivity of the DCDQ in the current sample of Australian children, highlight the difference in the nature of assessment for the two measures. The test items in the two measures were intended to assess gross and fine motor abilities of children including the ability to integrate visual and proprioceptive information; however, some differences in assessment exist between measures. Specific assessment of motor functions is seen in the MAND. These include eye-hand coordination, two-hand coordination, muscle power, and kinaesthetic integration. The DCDQ, on the other hand, seems to focus on a more general level of motor activity. It is possible that motor impairment shown in one measure may not be revealed in the other, as different aspects of motor functions were assessed. Moreover, construct-irrelevant variance in the DCDQ was introduced by questions that elicit factors other than motor function: “Your child’s performance in individual sport is better than in team sport” and “Your child is disinterested in or tends to avoid participating sport requiring good motor skills,” “Your child could be described as a bull in a china shop,” and “Fatigues easily, and appears to slouch and ‘fall out’ of chair if required to sit for long period.” A positive response to these questions could also be inferred as a state of anxiety or hyperactivity. It is reasonable to say

### Table 4 The DCDQ Scores for the Comparison, ADHD, MI and ADHD/MI Groups

<table>
<thead>
<tr>
<th></th>
<th>Comparison</th>
<th>ADHD</th>
<th>MI</th>
<th>ADHD/MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCDQ scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n)</td>
<td>55</td>
<td>30</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>M</td>
<td>70.84</td>
<td>56.43</td>
<td>58.05</td>
<td>55.54</td>
</tr>
<tr>
<td>SD</td>
<td>9.02</td>
<td>13.92</td>
<td>11.58</td>
<td>11.72</td>
</tr>
</tbody>
</table>

Discussion

The ability of the DCDQ to identify motor impairment in children in an Australian sample was examined using the MAND as the criterion measure. A low association between the DCDQ and the MAND was found in this study, indicating that the two measures largely assess different aspects of motor performance in the children. The overall decision agreement between DCDQ and MAND (67.4%) fails to meet the 80% satisfactory level for concurrent validity recommended by Riggen et al. (1990). This low overall agreement, however, is consistent with that reported in the European sample (kappa = .14; Green et al., 2005). In addition, the DCDQ was found to have low discrimination accuracy. The overall results obtained in this study suggest that the DCDQ as a screening tool is not highly proficient in discriminating children with MI from those without.

It has been pointed out that different motor tests used to identify children with DCD produce different samples of children (Larkin & Cermak, 2002). This situation, in part, reflects the heterogeneous nature of the motor problems in children with DCD. Motor tests designed to tap only a particular aspect of the motor function may fail to identify children with other forms of motor difficulties. On the other hand, the situation also reflects the characteristics of the population used to standardize the motor tests (Piek, 2006).

The findings of a low association between the MAND and the DCDQ, and the poor sensitivity of the DCDQ in the current sample of Australian children, highlight the difference in the nature of assessment for the two measures. The test items in the two measures were intended to assess gross and fine motor abilities of children including the ability to integrate visual and proprioceptive information; however, some differences in assessment exist between measures. Specific assessment of motor functions is seen in the MAND. These include eye-hand coordination, two-hand coordination, muscle power, and kinaesthetic integration. The DCDQ, on the other hand, seems to focus on a more general level of motor activity. It is possible that motor impairment shown in one measure may not be revealed in the other, as different aspects of motor functions were assessed. Moreover, construct-irrelevant variance in the DCDQ was introduced by questions that elicit factors other than motor function: “Your child’s performance in individual sport is better than in team sport” and “Your child is disinterested in or tends to avoid participating sport requiring good motor skills,” “Your child could be described as a bull in a china shop,” and “Fatigues easily, and appears to slouch and ‘fall out’ of chair if required to sit for long period.” A positive response to these questions could also be inferred as a state of anxiety or hyperactivity. It is reasonable to say
that the parent-reporting system in the DCDQ involves an element of subjectivity, although Green et al. (2005) reported that parent’s report was more reliable than teacher’s report when the DCDQ was used. Nonetheless, the use of retrospective information as in the case of the DCDQ may compromise the accuracy of the measure.

**ADHD Influence on the DCDQ**

The present study showed that the ADHD condition has an impact on the sensitivity of the DCDQ. The result revealed no statistically significant difference in the DCDQ scores among the ADHD, MI, and ADHD/IM groups. Children in the comparison group, however, obtained a statistically significantly higher DCDQ score compared with the other three groups. One possibility for this lack of group difference between the ADHD and the MI groups may be that the DCDQ was identifying the ADHD behavior as poor motor performance. In other words, the parents may be overidentifying children with ADHD as having motor problems, although this remains to be tested. This finding is consistent with Green et al. (2005) where a significant difference in the MABC Checklist scores (C-ABC; Henderson & Sugden, 1992) between children with and without ADHD was obtained, regardless of their DCD status. These authors suggested that the presence of ADHD affects the scores on the C-ABC. As discussed earlier, the construction of test items in the DCDQ may influence test scores. Besides measuring motor performance, the DCDQ may be tapping into other constructs, such as hyperactivity or inattention. The high number of false negatives identified by the DCDQ meant that half of the children with ADHD were incorrectly identified as having MI. The results demonstrate that the existence of an ADHD condition can limit the ability of the DCDQ to reliably differentiate children with ADHD from children with MI.

**Factors Influencing Measurement Accuracy**

The degree to which a test can effectively discriminate the presence or absence of a condition also depends on the test cut off score, the standard criterion measure against which the test is assessed, characteristic of sample, test norm standardization, and test cultural bias (Tan et al., 2001). Of particular interest to this study is the test cut-off score. Employing Green et al.’s (2005) method of calculating the sensitivity and specificity meant that the cut-off score for the DCDQ in the current study was no longer at the 10th percentile. Combining children with probable MI and suspected MI into one group increased the cut off score to the 25th percentile. A change in the cut-off score can affect its sensitivity and specificity (Portney & Watkins, 2000). Indeed, the DCDQ sensitivity was increased but its specificity was reduced. If the DCDQ cut-off score had been maintained at the 10th percentile, its sensitivity would have reduced by half. As the DCDQ was intended as a screening measure to identify children with possible MI before a more detailed motor assessment could be rendered, its test sensitivity appears more relevant than its test specificity. Therefore, raising the test cut-off score, which in turn increased its sensitivity as shown in the current study, allows more children with MI to be identified.
The degree of symptom severity also has an impact on the sensitivity of the DCDQ. In examining the descriptive data, the DCDQ was shown to be accurate in identifying children with MI when the symptoms are moderate to severe. Its accuracy was reduced by half when identifying children with mild MI, however. The low accuracy in identifying the mild MI group could have reduced the overall sensitivity of the DCDQ in the total sample. As a good screening measure, it should be adequately effective in identifying the condition regardless of the severity of the symptoms. The current study, however, showed that the DCDQ failed to adequately identify children with mild MI.

Cultural bias in terms of how the test items were formulated is another issue to consider. It has been recognized that different cultures prefer their own types of physical activities. Therefore, it cannot be assumed that a test item that is discriminative in a given country and culture will apply across other cultures (Miyahara et al., 1998). Differences in motor performance have also been shown in seemingly similar cultures. Livesey, Coleman, and Piek (2007) reported that 4-year-old Australian children showed better performance on most tasks on the Movement ABC compared with the American sample used to determine the norms for the test, although this difference disappeared in the 5-year-olds. As the DCDQ was originally developed using the Canadian population, cultural bias may have a role in influencing the test’s sensitivity.

**Implications**

In general, the DCDQ did not adequately identify MI in the current community sample of Australian children. The low positive predictive value of the DCDQ also brings its clinical utility into question. The descriptive data suggests, however, that the accuracy of the DCDQ in identifying severe and moderate MI were 100% and 89%, respectively, but its accuracy fell to 40% when identifying mild MI. This suggests that the effectiveness of the DCDQ as a screening tool is substantially compromised only when the target population has mild MI. In addition, the low association between the two tests also brings out the issue of different measures assessing different aspect of motor functions. This issue will remain in the DCD research, especially in the development of screening tool, until a gold standard in motor measurement is realized. Furthermore, we must also take heed of Messick’s (1995) caution that both meaning and values are integral to the concept of validity. An assessment of the test’s validity should include the social consequences of the interpretation of the score. Performance on the DCDQ can result in the child being labeled as having DCD and the value associated with the label and the impact it can have on the life of the child needs to be carefully considered, particularly where the adverse consequences are due to construct-irrelevant variance.

**Limitations of Study**

An issue that needs to be taken into consideration, is the prevalence of the condition in the sample (Goodman, 1997; Portney & Watkins, 2000). A high prevalence of MI would have increased the sensitivity and positive predictive value. The
number of children without MI in the current study was twice the number compared with the children with MI. This uneven ratio could therefore reduce the level of sensitivity and positive predictive value of the DCDQ.

Furthermore, the use of different criterion measures in different studies (e.g., Green et al., 2005; Wilson et al., 2000) makes comparison between studies difficult. As there is no gold standard for measuring motor skills (Dewey et al., 2002), the influence of a criterion measure against which the DCDQ is assessed cannot be ruled out.

Finally, it should be recognized that the current study only recruited children from the metropolitan area while excluding children from the rural regions, with the small sample limiting the range of socioeconomic status sampled. Hence, a replication of this study using a larger sample to include the above variables and with a standardized criterion measure is warranted to provide a more substantial finding.

**Recommendations for Future Research**

Overall the DCDQ, as presently constructed, has limited potential as a screening tool for use in clinical settings in Australian samples. When applied to the community sample, its screening property is compromised by its low sensitivity to detect children with mild MI and its inability to differentiate the ADHD symptoms. Therefore, we recommend caution in the use of the DCDQ as a screening tool in identifying children with possible DCD in the community and certainly advise against its use as the only method for group allocation of children with DCD in research studies. We also recommend future studies address the issue of increasing the DCDQ’s sensitivity by eliminating or reducing cultural bias and the impact of the ADHD condition. In addition, the test cut off score needs to be reassessed in order that the DCDQ can more accurately identify children with mild MI.

**References**


