Can the CBCL be used to Screen for Motor Impairment?

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Abstract

Aim: It has been suggested that one approach in identifying motor impairment in children is to use the Child Behavior Checklist (CBCL) as a screening tool. The current study examined the validity of the CBCL in identifying motor impairment. Method: A total of 398 children, 206 girls and 192 boys aged from 3 years 9 months to 14 years 10 months were assessed on the McCarron Assessment of Neuromuscular Development to determine their motor ability. Parents completed the CBCL. Results: The ‘Clumsy’ item on the CBCL was found to predict motor ability independent of the child’s age, sex and scores on other items of the CBCL. However, the sensitivity of the ‘Clumsy’ item in terms of identifying motor impairment was found to be a low 16.7% compared with specificity of 93.2%. The item ‘Not liked’ was also found to be a significant predictor of motor impairment. Interpretation: Although the ‘Clumsy’ and ‘Not liked’ items were found to have a relationship with motor ability, they should not be relied upon to categorize children as motor impaired versus not impaired. It is possible that these items may be better indicators of motor impairment in children with developmental disorders such as ADHD, but clinical samples are needed to address this.

Running title: CBCL as a screen for motor impairment
Poor motor coordination accompanies many developmental disorders, including Attention Deficit/Hyperactivity Disorder\(^1\),\(^2\), autism spectrum disorders\(^3\), and Reading Disorder\(^4\). It is the core deficit in Developmental Coordination Disorder (DCD), described by the DSM-IV\(^5\) as “a marked impairment in the development of motor coordination that significantly interferes with academic competence or daily living skills” (p.56). Children with DCD have low self-perceptions and self-worth\(^6\),\(^7\) and higher levels of anxiety\(^8\) and depression\(^9\). These children are less likely to engage in physical activity\(^10\), with consequences for physical health and social adjustment. It is therefore important to know if children with a diagnosed psychiatric disorder also have comorbid DCD or motor impairment to ensure that they receive the appropriate intervention.

Diagnosis of motor impairment is difficult as it is heterogeneous in nature\(^11\), with impairments including locomotion, ball skills, balance, or fine motor tasks such as handwriting or using a knife and fork. Although there is no gold standard measure of motor impairment, several tests are commonly used for school-age children. These include the Movement Assessment Battery for Children\(^12\), or the more recent second version\(^13\), the Bruininks-Oseretsky Test of Motor Proficiency\(^14\) or the more recent second version\(^15\), and the McCarron Assessment of Neuromuscular Development (MAND)\(^16\). However, these require individual assessment and take 30 - 40 minutes to administer. In addition to these performance tests, there are screening measures for motor impairment which parents or teachers can fill in, such as the Developmental Coordination Disorder Questionnaire (DCDQ)\(^17\), which have proven effective in identifying children at risk of DCD.

In a recent study examining the relationship between parent-reported motor problems, autistic symptoms and ADHD, Reiersen and colleagues\(^18\) used two items from the Child Behavior Checklist (CBCL)\(^19\), Item 36 – ‘Gets hurt a lot, accident-prone’, and Item 62 – ‘Poorly coordinated or clumsy’, to identify parent-reported motor impairment. Of note, participants with or without DSM-IV ADHD who showed no endorsement of these items rarely had clinically significant levels of autistic symptoms. However, significant autistic symptoms were seen in over 70% of children with the combination of DSM-IV ADHD and endorsement of both CBCL motor items. The authors did note that they could not find any published studies examining the relationship between these two CBCL items and examination-based motor impairment, so it was unclear what type or degree of motor impairment was likely in children classified using the CBCL motor items. Based on the above study, the CBCL motor items do appear to have some utility in identifying children with ADHD who warrant further assessment for autistic features, but the relationship of these CBCL items with examination-based motor impairment is still unclear. The CBCL is widely used for screening purposes, and if the motor items identified by Reiersen and colleagues do predict poor motor skills, they would provide a cost-effective way of determining which children should be more fully assessed for motor impairment.

Item 62 has been previously linked with psychiatric disorder in a Norwegian study by Novik\(^20\). Novik identified 8 CBCL items that were most strongly related to psychiatric diagnoses (determined through interview). These included the item identifying poor coordination (Item 62) plus items: 1 – ‘Acts too young for his/her age; 11-'Cling to adults or too dependent; 12 - ‘Lonely; 19 - Demands attention; 35 – Feels worthless or inferior; 48 – Not liked; and 103 –‘Unhappy, sad or depressed’. Most of the psychiatric
disorders identified by Novik were emotional disorders, and as DCD has been linked with emotional problems in the past, it is not surprising that a relationship was found.

The aim of the current study was to determine whether the CBCL can be used effectively to screen for children with motor impairment. If it proved effective in identifying children at risk of motor problems this would provide a simple and reliable way for practitioners to identify comorbid motor impairment in children with other psychiatric disorders in order to determine suitable intervention. Given the link between motor impairment and emotional problems such as anxiety and depression, the items found by Novik to be linked with psychiatric disorders were also evaluated to ensure that the ‘motor’ items are more effective at picking up motor impairment than these other items. The MAND was used as the criterion measure.

**Method**

**Participants**

A total of 404 children and adolescents were included in this study. However, five were removed due to incomplete data on the CBCL, and one other was removed as she was an extreme outlier. This left a total of 398 children (206 girls and 192 boys) aged from 3 years 9 months to 14 years 10 months (mean = 9 years 0 months). They had a mean MAND Neurodevelopmental Index (NDI) score of 96.33 (sd=15.54) with a range of 55 to 147. Of those found to have a motor impairment, 70 were mildly impaired (NDI index between 71 and 85) and 20 were moderately impaired (NDI index of 55 to 70). None were identified with a severe impairment.

Participants were recruited from 42 schools/preschools in the metropolitan region of Perth, Western Australia. Schools were chosen on the basis of their position on a state-wide index of student achievement, and therefore represented the distribution of academic achievement within the state. As this was a community sample, the presence of psychiatric symptoms was not considered as part of the selection process (see Dyck et al. for further details on the selection of this sample).

**Materials**

**McCarron Assessment of Neuromuscular Development (MAND)**. The MAND comprises 10 tasks, five assessing fine motor and five assessing gross motor skills. The scaled scores on each of these tasks are added and age norms, provided for children aged 3.5 to 18 years, are used to determine the NDI with a mean of 100 and standard deviation of 15. The MAND has been found to be a sensitive and valid measure of identifying motor impairment in Australian children. The reliability coefficients for each of the 10 tasks ranged from $r = .67$ to $r = .98$, with a total score reliability coefficient of $r = .99$.

**Child Behavior Checklist (CBCL)**. The CBCL was designed for children 4 to 18 years of age and lists symptoms that parents rate as ‘not at all true’ (0), ‘sometimes true’ (1), or ‘mostly true’ (2) of their child. Only 9 items were used in the current study, namely: Item 1 – ‘Acts too young for his/her age’; Item 11 – ‘Clings to adults’; Item 12 – ‘Lonely’; Item 19 – ‘Demands attention’; Item 35 – ‘Feels worthless or inferior’; Item 36 – ‘Gets hurt a lot, accident prone’; Item 48 – ‘Not liked’; Item 62 – ‘Poorly coordinated or clumsy’;
Item 103 – ‘unhappy, sad or depressed. As with the study by Reiersen et al.\textsuperscript{18}, the scores on these items were dichotomised to either 0, meaning no endorsement of the item, or 1 and 2, meaning the item was endorsed.

Procedure
Ethical approval for this study was obtained from the Human Research Ethics Committee at Curtin University. All testing was carried out with informed consent of both the participants and their parents in accordance with the guidelines set out by the Australian National Health and Medical Research Council. The data for this study were collected as part of a larger study which assessed children on a wide range of abilities including motor and empathic ability, intelligence, executive functioning and language in order to understand the relationship between these abilities and behavioral problems. These tests were assessed individually by trained assessors to each child during 3 to 4 separate testing sessions. The CBCL was sent home for parents to complete along with the consent form for the child’s participation in the project. Further details of the methodology can be found in Dyck et al.\textsuperscript{21}.

Statistical Methods
The data were initially analysed using a hierarchical regression procedure with NDI score as the criterion variable. In a hierarchical regression predictors are entered in a sequential fashion in which the order of entry is decided on theoretical grounds and not statistical grounds. The hierarchical regression reported here proceeded in three steps. On step 1 the predictors of age and sex were entered since we wished to control for these variables before evaluating the contribution of the other predictors. On step 2 the 7 CBCL items predictive of psychiatric disorders\textsuperscript{20} were added to the model. On step 2, prior to evaluating the contribution of items 36 and 62, we wanted to examine the contribution of these 7 CBCL items once age and gender were controlled for. On step 3 Items 36 and 62 were entered to examine whether these predictors accounted for variance in NDI beyond the variance accounted for by the 7 CBCL items entered on step 2. For any step, unique variance refers to the proportion of variance accounted for in the NDI by each predictor after the effects of the other predictors in the model are netted out. Unique variance is measured as the squared semi-partial correlation coefficient ($sr^2$). Variance accounted for in NDI by the predictors in combination is measured by $R^2$. Incremental variance, on the other hand, refers to the increase in the proportion of variance accounted for when a set of variables is added to a model and is assessed by $R^2$ change. An inspection of the incremental variance on the final step allows us to determine whether Items 36 and 62 account for any variance in predicting motor impairment (the NDI) once the other items identified with psychiatric disorder (Items 1, 11, 12, 19, 35, 48, 103) are accounted for. Statistical significance was evaluated at an alpha level of .05.

Statistical power of the study was calculated for the incremental variance on the final step of a hierarchical regression. Since the effects were expected to be small, power was calculated for a change in R Square of .02. Given an initial model with 9 predictors (age and sex as control variables, Items 1, 11, 12, 19, 35, 48, and 103) and $R^2 = .30$, in order to detect an incremental change in variance of $sr^2 = .02$ at alpha = .05 and power = .80, a sample size of 340 was required.
Discrimination validity was determined by dichotomising the NDI into children with (≤ 85) and without (>85) motor problems and then determining the sensitivity and specificity of the CBCL items in relation to the NDI categories. Finally, level of impairment was determined by categorising the children’s MAND NDI score based on the criteria for mild, moderate and severe disability and then determining the proportion of children identified by the CBCL in these categories.

Based on the standard residual, Mahalanobis Distance and Cook’s Distance, one case was found to be both unusual and influential for the combination of predictors. It was decided that this case did not belong to the population and was removed. There were missing values for the items measured for 5 participants and these participants were eliminated from the analysis.

**Results**

*Hierarchical Regression Between CBCL Items and NDI*

Table 1 reports the validities (zero –order correlations) for the relationships between the predictor variables and the criterion variable (NDI score) as well as the semi partial correlations for the final model in which all the predictors had been included. The zero order correlation is a correlation between variables in which no other variables have been controlled for. The semi-partial correlation is the correlation between the predictor and NDI controlling for the other predictors. An inspection of the zero order correlations shows that all items except Sex and Item 103 (unhappy, sad or depressed) were significantly related to the NDI at the .05 level. For the CBCL items a negative correlation indicates that endorsement of the item is associated with a lower NDI score.

A model including Age and Sex was examined on step 1 of the hierarchical regression. Age and sex in combination accounted for a statistically significant proportion of the variance in NDI scores, $F(2,395) = 4.458, p=.012, R^2 =.022$. Only age accounted for unique variance in the NDI, $t(395) = 2.974, p = .003 (sr^2 = .022)$. There were no sex differences in NDI, however older participants were associated with higher NDI scores.

On step 2, the 7 CBCL items predictive of psychiatric disorder were entered and added statistically significant incremental variance ($R^2_{\text{Change}}=.058; F_{\text{Change}}(7,388)=3.476, p=.001$). An inspection of unique variance within the model for step 2 showed that amongst the CBCL items, only Item 48 (‘not liked’) accounted for statistically significant unique variance ($t(388) = -2.504, p = .013 (sr^2 = .015)$. Participants that endorsed the item ‘not liked’ were associated with a lower score on the NDI. The other CBCL items in the model are redundant in the sense that they do not explain a statistically significant proportion of the variance in NDI once the other predictors have been controlled for. The statistically significant zero order correlations reported for items like for example item 11...
('Clings to adults') and item 1 ('Acts too young for his/her age') are spurious in the sense that they are explained by the variance they share with the other predictors.

Items 36 ('Gets hurt a lot, accident prone') and 62 ('Poorly coordinated or clumsy') were added to the model on step 3 and significantly increased the variance accounted for ($R^2_{\text{change}} = .021; F_{\text{change}}(2,386)=4.545, p=.011$). In the final model item 62 accounted for unique variance ($t(386) = -3.014, p = .003 (sr^2 = .021)$). However, item 36 was a redundant predictor ($t(386) = .780, p = .436 (sr^2 = .001$). In the final model, Item 48 remained a significant predictor ($t(386) = -2.44, p = .020 (sr^2 = .013$) as did age ($t(386) = 3.035, p = .003 (sr^2 = .021$).

**Discrimination accuracy**

Table 2 shows the number of cases identified by Item 62 as having motor impairment compared with those identified by the MAND. The sensitivity $[a/(a+c)]$ of CBCL Item 62 was 16.7% (Confidence Interval: 10.3% - 25.6%), whereas its specificity $[d/(b+d)]$ for identifying the absence of motor impairment was 93.2% (Confidence Interval: 89.8% - 95.5%). The positive predictive value of Item 62 was 41.7% $[a/(a+b)]$, indicating that less than half of the cases identified as having motor problems actually had them according to the MAND. Item 62 had a negative predictive value of 79.3% $[d/(c+d)]$, indicating that 21% of the cases identified as not having motor problems did have them according to the MAND score. Overall, the discrimination accuracy of the CBCL item was low.

**Level of impairment and CBCL identification**

Table 3 splits the cases into children identified by the MAND as either having no impairment (NDI>85), mild impairment (NDI between 71 and 85) and moderate impairment (NDI between 55 and 70). It can be seen that CBCL Item 62 identified only 8 of the 20 children with a moderate impairment (40%) and only 7 of the 70 children with a mild impairment (10%). When Item 48 was included, this increased to 10 of 20 children with a moderate impairment (50%) and 18 of the 70 children with a mild impairment (25.7%).

**Discussion**

A quick and effective screening tool to identify motor impairment in children that is also reliable and valid would be helpful in clinical practice and in large research studies where
individual assessment is costly and time-consuming. Two items from the CBCL, Items 36 and 62, have been previously used as indicators of parent-reported motor problems in an ADHD-enriched sample of 851 child and adolescent twins. In that study, these CBCL items were associated with autistic-like social impairment, particularly in children with ADHD. This result was expected given previous reports of the association between motor problems and autistic symptoms, but it was unclear what type or degree of motor impairment the CBCL items might indicate. The current study partially supported the utility of Item 62 as a significant predictor of motor ability. Item 36, however, was a redundant predictor and did not account for any unique variance in motor ability when considered in combination with Item 62. The statistically non-significant result for item 36 reflects a weak effect size rather than low statistical power. After controlling for the other predictors, Item 36 accounted for .001 of the variance in the NDI. This result suggests that item 36 does not provide a unique explanation of motor difficulties beyond the variance it shares with the items related to psychiatric disorders. The clinical significance of Item 62, however, is also low for the current study population. The clinical outcome of using Item 62 is a measure in which both the sensitivity (16.7%) and the positive predictive value (41.7%) are considerably lower than the acceptable level of 80% or more. Less than half of the total cases identified from Item 62 as having motor problems actually had these according to the MAND. Overall, the discrimination accuracy of the CBCL item was poor.

Item 62 was one of the 8 items of the CBCL that Novik identified as being predictive of psychiatric disorders in a sample of 1,170 children aged 4 to 16 years. By contrast, the current study showed Item 62 to have poor sensitivity and positive predictive value for motor ability. We also found another item, Item 48 (Not liked), explained unique variance in motor ability, although even when both Items 48 and 62 were used to identify motor impairment, sensitivity and positive predictive value remained low at 31.1% and 38.9% respectively.

A relationship between being liked and motor ability has been reported elsewhere. Chase and Dummer examined the determinants of social status in children, and found that boys rated athletic ability and physical appearance as the most important determinants of social status for males. Young girls viewed physical appearance as the single most important determinant of social status for both boys and girls. It should be noted that children with poor motor ability are more often overweight, which may lead to low perceptions of their physical appearance. Other studies cite poor social support, and poor peer integration in children with movement problems. Also, being described as “not liked” may sometimes be a result of autistic-like social impairment, so the association between motor impairment and this CBCL item could be partly due to the high prevalence of motor impairment in autism spectrum disorders.

Novik also pointed out that both school psychologists and paediatricians in Norwegian schools now use the CBCL for screening behavioural and emotional problems, but warns that the predictive value depends on the prevalence of the disorder. Novik had a prevalence of 20% and suggests a lower prevalence would reduce the predictive value. This may account for the low sensitivity and positive predictive values identified in the
current study. Although the overall prevalence of motor impairment was 22.6%, 78% of these only had mild motor impairment. Only 5% of the total sample had a moderate impairment, and no individual had a severe impairment. Also, caution should be used when speculating about the likely degree of motor impairment in the participants studied by Reiersen and colleagues since their sample was enriched for ADHD and the current sample was not. Future research should consider investigating the CBCL in a sample of children with more severe motor impairment, as well as in children with a variety of developmental disorders. Furthermore, some screening tools for motor impairment have been found to be less effective in children with developmental disorders such as ADHD, as symptoms may be misdiagnosed as clumsiness.

In general, the use of screening instruments to identify motor impairment has had limited success. Recent instruments, such as the DCDQ have focused on the performance of daily activities that require motor coordination to determine whether such activities have been disrupted. These behaviours are more easily recognised by parents and teachers, and they generally cover several aspects of movement control. A recent investigation of the DCDQ found that this test had low specificity and sensitivity when the MAND was used as the criterion variable. However, the DCDQ was found to be accurate in identifying children with moderate or severe motor impairment. Since the current study did not include children with severe motor dysfunction based on the MAND, it is still unclear how accurate the CBCL would be in identifying children with severe motor impairment. Given that the CBCL only includes the one item related specifically to motor ability, and the very general nature of this item (i.e., ‘Poorly coordinated or clumsy’), it is not surprising that it lacks predictive validity in the sample studied here.

In conclusion, although the CBCL has excellent psychometric characteristics, is frequently used, and has well-established norms, the current study does not support the use of the single ‘clumsy’ item to identify mild to moderate motor impairment in non-clinical populations.

Acknowledgments
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References
Table 1. Zero order and semi-partial correlations between the predictor variables and the dependent variable (NDI). For the zero-order correlations, the Pearson Product Moment Correlation is reported for age and the point biserial correlation is reported for the remaining predictors. The semi-partial correlations are for the final model with all predictors included. N=398

<table>
<thead>
<tr>
<th>Predictor variable</th>
<th>Correlation</th>
<th></th>
<th></th>
</tr>
</thead>
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<tr>
<td></td>
<td>(coding)</td>
<td>Zero-order</td>
<td>Semi-partial</td>
</tr>
<tr>
<td>Sex</td>
<td>(0 = male, 1 = female)</td>
<td>.011</td>
<td>.025</td>
</tr>
<tr>
<td>Age</td>
<td>.142**</td>
<td>.146**</td>
<td></td>
</tr>
<tr>
<td>Item 1</td>
<td>(0 = not endorsed, 1 = endorsed)</td>
<td>-.148**</td>
<td>-.086</td>
</tr>
<tr>
<td>Item 11</td>
<td>(0 = not endorsed, 1 = endorsed)</td>
<td>-.164***</td>
<td>-.086</td>
</tr>
<tr>
<td>Item 12</td>
<td>(0 = not endorsed, 1 = endorsed)</td>
<td>-.098*</td>
<td>-.005</td>
</tr>
<tr>
<td>Item 19</td>
<td>(0 = not endorsed, 1 = endorsed)</td>
<td>-.116*</td>
<td>.020</td>
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<tr>
<td>Item 35</td>
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<td>-.118*</td>
<td>-.061</td>
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<td>.038</td>
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<tr>
<td>Item 48</td>
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<td>-.157**</td>
<td>-.113*</td>
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<td>-.187***</td>
<td>-.145**</td>
</tr>
<tr>
<td>Item 103</td>
<td>(0 = not endorsed, 1 = endorsed)</td>
<td>-.056</td>
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Note: *p< .05; ** p< .01, ***p < .001 (two-tailed).
Table 2  Number of cases identified by the CBCL-Item 62 compared with the MAND. MI=Motor Impairment, NDI = Neurodevelopmental Index.

<table>
<thead>
<tr>
<th>MAND (NDI)</th>
<th>MI</th>
<th>non-MI</th>
<th>Total</th>
</tr>
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<tr>
<td>MI*</td>
<td>15\textsuperscript{a}</td>
<td>21\textsuperscript{b}</td>
<td>36</td>
</tr>
<tr>
<td>Non-MI</td>
<td>75\textsuperscript{c}</td>
<td>287\textsuperscript{d}</td>
<td>362</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>308</td>
<td>404</td>
</tr>
</tbody>
</table>

\textsuperscript{a} true positive; \textsuperscript{b} false positive; \textsuperscript{c} false negative; \textsuperscript{d} true negative
Table 3  Number of cases identified by A. the CBCL-Item 62 and B, combined CBCL items 48 and 62 (one or both items endorsed) compared with the NDI sub-categories. MI=Motor Impairment, NDI=Neurodevelopmental Index.

<table>
<thead>
<tr>
<th>MAND (NDI)</th>
<th>Moderate MI</th>
<th>Mild MI</th>
<th>no-MI</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>A. CBCL Item 62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>8</td>
<td>7</td>
<td>21</td>
<td>36</td>
</tr>
<tr>
<td>Non-MI</td>
<td>12</td>
<td>63</td>
<td>287</td>
<td>362</td>
</tr>
<tr>
<td>B. CBCL Items 48 &amp; 62</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>10</td>
<td>18</td>
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<tr>
<td>Non-MI</td>
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<td>326</td>
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<tr>
<td>Total</td>
<td>20</td>
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