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BRIEF REPORT

# Brief Report: Children with ADHD Without Co-morbid Autism do not have Impaired Motor Proficiency on the Movement Assessment Battery for Children

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**Abstract** Motor proficiency was investigated in a sample of children with Attention Deficit Hyperactivity Disorder-Combined type (ADHD-CT) without autism. Accounting for the influence of co-morbid autistic symptoms in ADHD motor studies is vital given that motor impairment has been linked to social–communication symptoms in children who have co-morbid ADHD and autistic-like symptoms. Two groups of children aged between 7–14 years were recruited; children with ADHD-CT (n = 16; mean age 10 years, 7 months [SD = 1 year, 10 months]) and a typically developing (n = 16; mean age 10 years, 6 months [SD = 2 years, 6 months]) group. Motor proficiency was measured using the Movement Assessment Battery for Children-2nd Edition, ADHD symptoms were measured using the Conner's Parent Rating Scale. Children with ADHD-CT who had been screened for co-morbid autism did not display motor difficulties on the MABC-2. Higher levels of inattention, but not hyperactivity or impulsivity were associated with poorer motor performance. These findings provide indirect evidence that the motor problems that children with ADHD experience may be related to co-occurring social responsiveness impairments.

**Keywords** Autism · ADHD · Co-morbidity · Motor performance

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders, affecting approximately 3–7 % of school aged children (APA 2000). Neuroimaging studies reveal abnormalities in brain structure and function for ADHD, although the precise pathogenesis of this disorder still remains unclear (Konrad and Eickhoff 2010). The DSM-IV-TR (APA 2000) describes three subtypes of ADHD; predominantly Hyperactive-Impulsive subtype, predominantly Inattentive subtype (ADHD-PI), and a Combined type (ADHD-CT) which includes a combination of inattentive, impulsive, and hyperactive symptoms. In addition to psychosocial complications, up to 50 % of children with ADHD are reported to show motor coordination ability below age expected performance (Piek et al. 1999).

Investigations using standardized motor batteries commonly report motor disturbances in individuals with ADHD (Pan et al. 2009; Brossard-Racine et al. 2011; Piek et al. 1999; Reiersen et al. 2008). Additionally, the type and degree of motor impairment has been shown to differ between subtypes, with the ADHD-PI showing significantly poorer fine motor skills, while children with ADHD-CT show more difficulty with gross motor skills (Piek et al. 1999). Piek et al. (1999) also investigated the relationship between core clinical ADHD symptoms and motor problems indicating that the severity of children's inattentive symptomatology was found to predict motor coordination difficulties. Additionally, inattention in ADHD-CT has been shown to be associated with the presence of motor problems on the Children Behaviour Checklist-Parent Report (Reiersen et al. 2008).

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The association between motor problems and inattention has also been demonstrated in motor studies that have investigated the effect of medication known to enhance attention/cognitive abilities on motor performance in ADHD. A recent study conducted by Brossard-Racine et al. (2012) investigated the effect of medication (methylphenidate) on motor proficiency using the Movement Assessment Battery for Children (MABC). A subset of children (approximately 20 %) with ADHD (n = 9) were found to perform better on the MABC after the administration of methylphenidate over a 3 month period. This provides preliminary evidence that motor problems may in part be associated with core inattentive symptoms in ADHD.

The combination of autistic and ADHD symptoms present in a given individual may also underlie some of the motor problems commonly reported in children diagnosed with ADHD. It has been reported that nearly one-third of boys with population-defined ADHD-CT meet clinical cut-offs for autistic symptomatology however, this is not traditionally considered in studies of motor functioning (Reiersen et al. 2008). Of particular relevance, a large cohort study (n = 851), found that children with a combination of ADHD and parent-reported autistic symptoms exhibited greater movement difficulties measured on the Child Behaviour Checklist (Reiersen et al. 2008).

A meta-analysis by Fournier et al. (2010) has suggested that motor features are a persistent clinical feature of Autism Spectrum Disorders (ASD). Neuroimaging studies suggest an association between brain structure, core ASD symptoms and motor disturbance, for example, Qiu et al. (2010) reported that abnormalities in the basal ganglia correlated with core ASD symptoms as measured by the Autism Diagnostic Observation Scale (ADOS) and motor impairment as measured by the Physical and Neurological Examination of Subtle Signs (PANESS). Our own work has shown that children with ASD who experience greater difficulties with social responsiveness also experience greater motor problems on the MABC (Papadopoulos et al. in press).

The question as to whether autism and ADHD should be co-morbidly diagnosed has been a topic of great interest recently (see Gargaro et al. 2011 for a review). The current diagnostic classification system precludes a dual diagnosis of autism and ADHD (APA 2000). Despite this, it is well documented that children with ASD show ADHD behaviours such as hyperactivity, impulsivity and attentional deficits (Goldstein and Schewebach 2004), and similarly young people with ADHD often experience social-communicative difficulties (Clark et al. 1999; Geurts et al. 2008).

A recent study conducted by Grzadzinski et al. (2010) indicated that the co-morbid autistic traits evident in a subgroup of individuals with ADHD could not be accounted for by the primary impulsive, hyperactive, and inattentive behaviours of ADHD. Thus, children with ADHD with comorbid autistic symptoms may form a subgroup with a common genetic pathway, consistent with the reported genetic overlap in autism and ADHD (Nijmeijer et al. 2010).

The aim of this study is to investigate motor difficulties, as measured by motor proficiency scores on the Movement Assessment Battery for Children (MABC-2) in children with ADHD without autism.

It was hypothesised that there would be no difference in motor proficiency between a sample of individuals diagnosed with ADHD-CT without autism and a sample of Typically Developing (TD) controls. Additionally, based on Piek et al. (1999) and Reiersen et al. (2008) findings that inattention is associated with motor problems in children with ADHD, it was further predicted that inattentive symptoms measured on the Conner's Rating Scale (CRS) would be associated with greater deficits in motor proficiency.

## Method

### Participants

Sixteen boys diagnosed with ADHD-CT aged between 7 and 14 years were recruited from a private Pediatrician clinic in Melbourne. Paediatricians referred children with a diagnosis of ADHD-CT who had been screened for autistic disorder, Asperger's disorder or pervasive developmental disorder not otherwise specified. Exclusion criteria included a co-morbid medical (e.g. tuberous sclerosis), hearing or visual, or genetic (e.g. Fragile X syndrome) disorder other than the primary diagnosis of ADHD-CT as described in Langmaid et al. (in press). No participants were excluded for having these conditions. Additionally, a doctoral level trained graduate student interviewed parents to review the child's medical, developmental and behavioural history, to confirm that the child met criteria for ADHD-CT according to the DSM-IV-TR. Participants were also administered the Conner's Rating Scale Parent report (Conners 2001), and further screened for a possible autism diagnosis using the Autistic Diagnostic Observation Scale (ADOS) by a researcher trained in administration, author (NP). No participants met the criteria for autistic disorder on the ADOS and thus no clinical participants were excluded from the study.

The majority of participants in the study (13/16) were on stimulant medication such as methylphenidate (Ritalin). Participants discontinued medication at least 24 h prior to testing (Langleben et al. 2006; Leitner et al. 2007).

Sixteen typically developing boys aged between 7 and 12 years with no prior history of psychological, neurological or psychiatric diagnoses were recruited from local schools and the local community.

Intellectual functioning was measured for all participants in both groups using the Weschler Intelligence Scale for Children 4th Edition (WISC-IV) (Wechsler 2005) with the exception of two clinical participants who did not complete a cognitive assessment. A series of Independent samples $t$ tests were conducted to investigate the effect of age and IQ between the two groups. There was no significant difference in age ($t(30) = 0.172$, $p = 0.865$), Full Scale Intelligence Quotient (FSIQ) ($t(28) = 1.37$, $p = 0.183$), Verbal Comprehension Index (VCI) ($t(28) = 1.78$, $p = 0.087$) and Perceptual Reasoning Index (PRI) ($t(28) = 0.565$, $p = 0.580$) between the groups (see Table 1).

## Measures

### *Motor Proficiency*

Motor proficiency was measured using an age appropriate measure of motor performance: the Movement Assessment Battery for Children (MABC-2) (Henderson et al. 2007). The MABC-2 has been found to have good reliability with Pearson's coefficients of .77, .84, .75 and .80 for manual dexterity, aiming and catching, balance and total MABC-2 score respectively (Henderson et al. 2007). Inter-rater reliability coefficients ranging from .51–.71 have been reported for the first age band (3–6 years) (Ellinoudis et al. 2011), however, no study has yet reported inter-rater reliability for the older age bands used in this study. The MABC has been previously used in children with ADHD. It comprises of a total of eight tasks grouped into three subtests; manual dexterity, aiming and catching and balance. Percentile ranks and age-adjusted standard scores are provided for subtest scores and total impairment scores. Higher percentile ranks/scores on the MABC-2 indicate better motor proficiency. The MABC-2 was administered by a graduate student who had undergone training in the administration and scoring of the MABC-2, from a Physiotherapist. The MABC-2 was conducted in a standardized test setting at the Clinical Research Centre for Movement Disorders and Gait, Kingston Centre, Melbourne.

Severity of total ADHD symptoms (CRS-total score), severity of Inattention (CRS-Inattention Score) and severity of hyperactivity (CRS-hyperactivity score) symptoms were measured using the Conner's Rating Scale (CRS)-Parent report. Raw scores were converted to t-scores, where a higher t-score indicates greater severity of ADHD symptoms experienced.

**Table 1** Participant characteristics

| | ADHD | Typically developing controls (TD) |
|---|---|---|
| No. of participants | 16 | 16 |
| Age mean (SD) | 10 years, 7 months (1 year, 10 months) | 10 years, 6 months (2 years, 6 months) |
| FSIQ mean (SD)[a] | 97.50 (12.48) | 104.88 (16.50) |
| VCI mean (SD)[a] | 94.79 (13.44) | 104.88 (17.13) |
| PRI mean (SD)[a] | 102.50 (14.53) | 105.69 (16.38) |
| CRS total ADHD score | 62.1 (9.9) | 44.4 (3.3) |
| CRS inattention score | 59.9 (10.2) | 45.4 (5.1) |
| CRS hyperactivity score | 65.2 (14.1) | 47.6 (5.9) |

[a] Cognitive assessment was not completed for two of the ADHD participants

## Data Analysis

A series of Independent samples $t$ tests were conducted to assess group differences in Total MABC-2 and its three component subtest scores. Spearman correlations were conducted on the ADHD group data ($n = 16$) to investigate the association between movement impairment and Inattention, Hyperactivity and Impulsivity measured on the Conner's Rating Scale.

# Results

## Motor Proficiency

The motor proficiency total and subtest percentile scores of the MABC-2 are illustrated in Fig. 1. There were no significant differences between the ADHD ($M = 80.8$, SD = 12.5) and TD ($M = 82.0$, SD = 12.7) groups when compared on total mean MABC-2 percentile scores ($t(30) = 0.27$, $p = 0.792$). Additionally there were no significant differences between the mean percentile scores for the ADHD and TD groups across the three subtests: manual dexterity ($t(30) = .44$, $p = 0.662$; ADHD; $M = 36.8$, SD = 28.7, TD; $M = 32.8$, SD = 23.8), throwing and catching ($t(30) = .220$, $p = 0.827$; ADHD; $M = 64.2$, SD = 26.0), TD; $M = 66.3$, SD = 27.8) and balance ($t(30) = .449$, $p = 0.657$, ADHD; $M = 61.4$, SD = 28.7, TD; $M = 66.4$, SD = 34.1).

## Clinical Correlations

There was a significant negative correlation between Inattention scores and Total MABC-2 ($n(16)$, $r_s = -0.58$, $p = 0.02$) (Higher scores on the Inattention-CRS reflect greater inattentive symptoms, while the lower percentile scores on the MABC-2 reflect poorer motor performance).

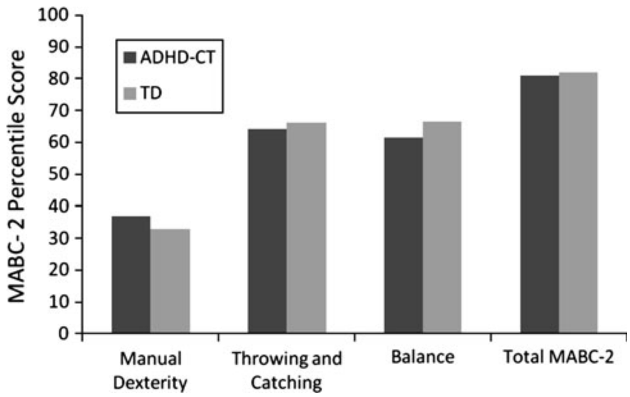


**Fig. 1** Movement proficiency (mean percentile ranks) measured on the Movement Assessment Battery for Children-2. Percentile rank represents the proportion of same aged peers with a lower score (e.g. 25th percentile is interpreted as 25 % of same age peers with an equivalent or lower score)

Inattention was also significantly correlated with the ball skills subtest ($n(16)$, $r_s = -0.69$, $p = 0.003$) but not the manual dexterity and balance subtest ($p > 0.05$, see Fig. 2a, b). There was no significant correlation between Hyperactive-Impulsive symptoms ($n(16)$, $r_s = -0.046$, $p = 0.867$) and total MABC-2 score or subtest scores.

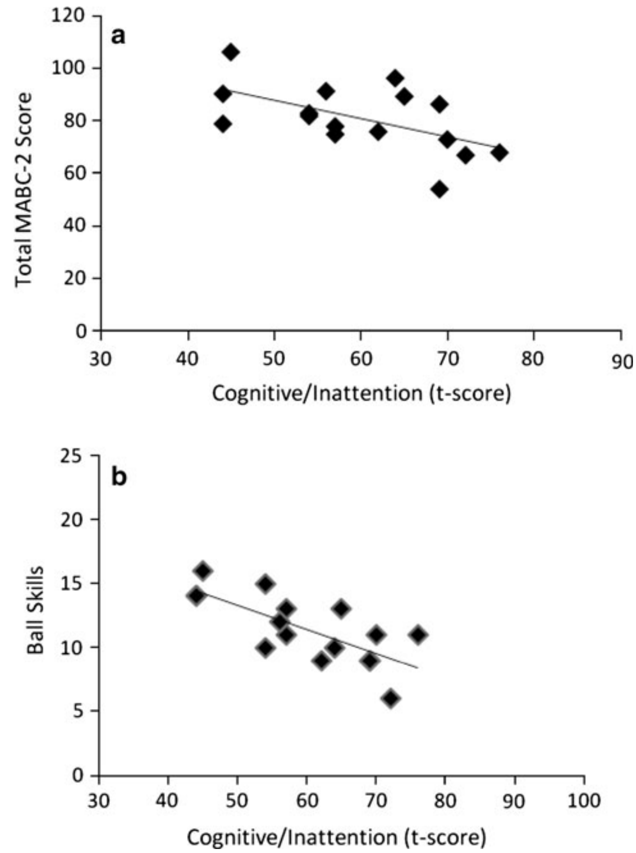


**Fig. 2** **a** A significant negative correlation between inattention and mean total movement impairment percentile score, $n(16)$, $r_s = -0.581$, $p = 0.02$. **b** A significant negative correlation ($n(16)$, $r_s = -0.686$, $p = 0.003$) between the ball skills subtest of the MABC-2 and inattention

## Discussion

This study aimed to investigate motor proficiency in a well defined sample of individuals diagnosed with ADHD-CT without autism. In contrast to past studies, the current study excluded autism using DSM-IV criteria in addition to the "gold standard" autistic diagnostic measure: the Autism Diagnostic Observation Scale (ADOS-G) (Lord et al. 2000). Our hypothesis, that children with ADHD-CT without co-morbid autistic symptoms would not display motor difficulties was supported. The findings that children with "ADHD only" in this sample did not have motor difficulties contrasts with previous research that commonly report motor deficits in children with ADHD (e.g. Piek et al. 1999). These findings suggest that it may be that the co-morbid autistic symptoms in children with ADHD contribute to more impaired motor proficiency difficulties.

As predicted, inattention, but not hyperactivity or impulsivity, correlated with degree of motor proficiency deficits in children with ADHD. Higher levels of inattention were associated with greater motor impairment in ADHD. This could be interpreted in the context of a recent neuropsychological review by O'Halloran et al. (2012) who commented on parallel development of brain regions such as the cerebellum responsible for both motor and cognitive (attentional) processes.

There are several limitations to this study. The use of a standardized motor measure may have limited our ability to detect subtle motor anomalies commonly reported in individuals with ADHD. Additionally, it may be that this sample comprised of the "milder type" of ADHD, and that motor deficits in "ADHD-CT only" only become apparent in individuals who exhibit greater severity of ADHD symptoms. Two clinical participants did not complete a cognitive assessment, however there was no evidence to suggest that these children had impaired intellectual function. It is possible that this study was underpowered and we acknowledge that these findings are preliminary and exploratory and require further replication with a larger sample size. Future research using motor tasks which can detect the more subtle aspects of motor impairment which have previously been suggested by the literature, e.g. motor timing deficits (Buderath et al. 2009) for samples of individuals diagnosed with ADHD only, autism only and a subgroup of individuals with autism and ADHD, will enable a closer investigation of the interplay between autistic symptoms, ADHD symptoms and motor functioning in autism and ADHD.

## Conclusions

This study is the first to our knowledge to describe the motor profile of a well-defined group of individuals diagnosed with ADHD-CT without autism. Preliminary findings indicate that children with ADHD-CT who do not exhibit co-morbid autism do not have impaired motor proficiency. Inattentive symptoms were shown to correlate with overall movement impairment. These findings provide indirect evidence that co-morbid autistic symptoms that may be present in ADHD samples may contribute to motor difficulties commonly reported in ADHD (e.g. Reiersen et al. (2008) study). These findings have important clinical implications as motor symptoms in ADHD may serve as a useful “red flag” in identifying autistic symptoms.

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**Conflict of interest** Nicole Rinehart is a professor at Monash University and is also a clinical psychologist who consults at the Melbourne Children’s Clinic where children with ADHD were recruited from. Assoc. Professor Rinehart is also a member of the Australian National Health and Medical Research Council Expert Working Group on ADHD Clinical Practice.

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