



# Motor skills in Czech children with attention-deficit/hyperactivity disorder and their neurotypical counterparts



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## ABSTRACT

Attention-deficit/hyperactivity disorder (ADHD) is the most commonly diagnosed neurobehavioural disorder. Characterized by recurring problems with impulsiveness and inattention in combination with hyperactivity, motor impairments have also been well documented in the literature. The aim of this study was to compare the fine and gross motor skills of male and female children with ADHD and their neurotypical counterparts within seven skill assessments. This included three fine motor tasks: (1) spiral tracing, (2) dot filling, (3) tweezers and beads; and four gross motor tasks: (1) twistbox, (2) foot tapping, (3) small plate finger tapping, and (4) large plate finger tapping. It was hypothesized that children with ADHD would display poorer motor skills in comparison to neurotypical controls in both fine and gross motor assessments. However, statistically significant differences between the groups only emerged in four of the seven tasks (spiral tracing, dot filling, tweezers and beads and foot tapping). In line with previous findings, the complexity underlying upper limb tasks solidified the divide in performance between children with ADHD and their neurotypical counterparts. In light of similar research, impairments in lower limb motor skill were also observed. Future research is required to further delineate trends in motor difficulties in ADHD, while further investigating the underlying mechanisms of impairment.

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## 1. Introduction

Attention-deficit/hyperactivity disorder (ADHD; also referred to as hyperkinetic disorder by the World Health Organization, 1993) is the most commonly diagnosed neurobehavioural disorder. Affecting approximately 3% to 6% of school aged children (Banerjee, Middlerton, & Faraone, 2007; Brown et al., 2008; Polanczyk, Lima, Horta, Biederman, & Rhode, 2007), prevalence rates are estimated at 5.29% worldwide. Occurrence of ADHD is greater in male children, where estimates indicate boys out-represent girls by 2:1 to 9:1 (Rucklidge, 2010). Individuals with ADHD typically present with co-morbidities, such as other neurological and psychiatric diseases (Barkley, 2003; Polanczyk et al., 2007). The most commonly reported co-morbidities include oppositional defiant disorder, conduct disorder, affective and anxiety disorders (American Psychiatric Association, 2000; Kadesjö & Gillberg, 2001; Melnick & Hinshaw, 2000). Nevertheless, researchers have also

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noted reading disabilities, developmental coordination disorder and immature moral development in ADHD (e.g., [Hinshaw, Herbsman, Melnick, Nigg, & Simmel, 1993](#); [Kadesjö & Gillberg, 2001](#); [Visser, 2003](#)).

ADHD has been described by numerous authors during the last 200 years (see [Goldstein & Morewitz, 2011](#); [Lange, Reichl, Lange, Tucha, & Tucha, 2010](#)). A diagnosis of ADHD according to the diagnostic and statistical manual of mental disorders (DSM-IV-TR) requires six or more symptoms of inattention or hyperactivity-impulsivity, which have persisted for at least 6 months ([American Psychiatric Association, 2000](#); [Biederman & Faraone, 2005](#); [Lange, Reichl, Lange, Tucha, & Tucha, 2010](#)). Based on these criteria, three specific subtypes can be identified: Predominantly inattentive (ADHD-PI), predominantly hyperactive-impulsive (ADHD-HI) and the combined type (ADHD-C), which is more prevalent and results in greater impairment ([American Psychiatric Association, 2000](#); [Rohde & Halpern, 2004](#)).

In comparison to the DSM-IV-TR, the [World Health Organization \(1993\)](#) uses hyperkinetic disorder (HD) to describe a full set of symptoms in the domains of inattention, hyperactivity and impulsivity in the International Classification of Diseases (ICD). The primary difference between the two means of diagnosis include DSM-IV-TR (ADHD) criteria recognizing three subtypes of ADHD, whereas ICD-10 criteria requires a full set of symptoms in all three domains; there is a narrower category. Nonetheless, it is suggested that nearly all children diagnosed with hyperkinetic disorder should also be included within the ADHD classification ([Taylor et al., 2004](#)), where it is postulated that an ICD-10 diagnosis of HD is the most congruent with the DSM-IV-TR diagnosis of ADHD-C ([Döpfner, Breuer, Wille, Erhart, & Ravens-Sieberer, 2008](#)). Children in the current study were diagnosed according to ICD criteria.

In addition to the above mentioned behavioural manifestations (i.e., inattention, hyperactivity and impulsivity) which are used for diagnostic purposes, motor impairments associated with ADHD have been well documented in the literature (e.g., [Harvey & Reid, 1997](#); [Harvey et al., 2007](#); [Pitcher, Piek, & Hay, 2003](#)). A review of 49 studies published between 1949 and 2002 ([Harvey & Reid, 1997](#)) concluded that impaired movement skills are more likely to manifest in children with ADHD in comparison to neurotypical peers. It is generally accepted that between 30% and 50% of children with ADHD have motor impairments, which can undoubtedly affect daily life ([Barkley, DuPaul, & McMurray, 1990](#); [Fliers et al., 2010](#); [Hartsough & Lambert, 1985](#); [Piek, Pitcher & Hay, 1999](#); [Pitcher et al., 2003](#); [Visser, 2003](#)). In light of these observations, children with ADHD are typically described as 'clumsy' ([Tervo, Azuma, Fogas, & Flechtner, 2002](#)). More specifically, children with ADHD lag behind their neurotypical peers with respect to the development of speed and timing, balance, and suppression of contralateral overflow movements—all key components in the overall development of motor control skills ([Denckla & Rudel, 1978](#)). As such, Scandinavia countries have implemented the term Deficits of Attention and Motor Perception (DAMP) to describe children with a combination of ADHD and motor impairments ([Fliers et al., 2008](#)).

A plethora of studies have incorporated different assessments to measure motor skills in children with ADHD. For example, the Physical and Neurological Examination for Subtle Signs (PANESS; [Denckla, 1985](#)) has been used to differentiate children with ADHD from their neurotypical counterparts ([Cole, Mostofsky, Larson, Denckla, & Mahone, 2008](#); [Schuerholz, Cutting, Mazzocco, Singer, & Denckla, 1997](#)). Harvey and colleagues ([Harvey and Reid, 1997](#); [Harvey et al., 2007](#)) used the Test of Gross Motor Development (TGMD; [Ulrich, 1985](#); TGMD-2; [Ulrich, 2000](#)) to examine gross motor skills in children with ADHD. The authors observed significant differences between children with ADHD and their neurotypical counterparts; such that below average performance was observed in children with ADHD ([Harvey & Reid, 1997](#); [Harvey et al., 2007](#)).

[Harvey and Reid \(1997\)](#) observed that children with ADHD demonstrated fewer performance criteria on locomotor skills (slide, horizontal jump, skip, lead, hop, gallop and run) and object control skills (overhand throw, kick, catch, stationary bounce, and two-hand strike). These results were replicated by [Pan, Tsai, and Chu \(2009\)](#), thus highlighting impaired gross motor development, locomotor control and object control. In a similar study, [Pitcher et al. \(2003\)](#) used the Movement Assessment Battery for Children (MABC; [Henderson & Sugden, 1992](#)) and the Purdue Pegboard ([Tiffin & Asher, 1948](#); [Tiffin, 1968](#)) to investigate both fine and gross motor abilities of male children with ADHD and their neurotypical counterparts. The authors observed an increased prevalence of movement impairments in all three subtypes of children with ADHD: ADHD-PI (58%), ADHD-HI (49%) and ADHD-C (47%), consistent with developmental coordination disorder (DCD).

A very recent study ([Goulardins, Marques, Casella, Nascimento, & Oliveira, 2013](#)) used the Motor Development Scale (MDS; [Rosa Neto, 2002](#), cf. [Goulardins et al., 2013](#)) to assess the motor profile of children with ADHD-C. Results revealed that the general motor quotients in all areas investigated were significantly lower in children with ADHD in comparison to neurotypical controls; however, in most cases, these values were still in the normal range. Consistent with previous clinical and epidemiological studies (e.g., [Fliers et al., 2008](#); [Pitcher et al., 2003](#)) 41% of children with ADHD displayed atypical motor skills, which the authors suggested to result from cortical maturation delay in prefrontal regions (see [Shaw et al., 2007](#)). Overall, the aforementioned studies highlight that children with ADHD may possess an inherent risk for developmental delays in motor skill performance.

In addition to studies which have incorporated general assessments of fine and gross motor skills, researchers have investigated specific motor skills of children with ADHD as well. In North America, writing performance has been anecdotally observed in ADHD ([Barkley, 1998](#)), such that a review from 1966 to 2006 revealed impaired performance in this population ([Racine, Majehemer, Shevall, & Snider, 2008](#)). It has also been noted that children with ADHD show impairments in learning and motor skills (e.g., typing; [Karatekin et al., 2002](#)), which is further exaggerated in complex tasks ([Barkley, 1998](#)).

In other parts of the world, similar findings have been observed. For example, [Pitcher et al. \(2003\)](#) observed children with ADHD had significantly impaired gross and fine motor abilities in comparison to neurotypical controls. That said the motor performance of numerous children with ADHD paralleled that seen in developmental coordination disorder (DCD). [Flapper, Houwen, and Schoemaker \(2006\)](#) reported that children with ADHD displayed poor manual dexterity, had poor handwriting

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