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Executive function and attention in young adults with and without Developmental Coordination Disorder – A comparative study

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ABSTRACT

The current research aimed at examining the executive function (EF) of young adults with Developmental Coordination Disorder (DCD) in comparison to young adults without DCD. The study used a randomized cohort ($N = 429$) of young adults with DCD ($n = 135$), borderline DCD ($n = 149$) and control ($n = 145$), from a previous study. This initial cohort was asked to participate in the current study three to four years later. Twenty-five individuals with DCD (mean age = 24 years, 1 month [SD = 0.88]; 18 males), 30 with borderline DCD (mean age = 24 years, 2 month [SD = 0.98]; 18 males) and 41 without DCD (mean age = 25 years, 2 months [SD = 1.91]; 20 males) participated in this study. Participants completed the BRIEF-A questionnaire, assessing EF abilities and the WURS questionnaire, assessing attention abilities. The DCD and borderline DCD groups had significantly lower EF profiles in comparison with the control group but no significant differences were found between the DCD and borderline DCD groups. While a high percentage of attention problems were found in both DCD groups, the executive functioning profiles remained consistent even when using the attention component as a covariate. The study results suggest that young adults with DCD have EF problems which remain consistent with or without attention difficulties.

1. Introduction

Executive functions (EF) are higher order cognitive processes required to perform novel or complex goal-directed tasks (Barkley, 1997). Research has indicated that EF processes, such as inhibition, anticipating and forward task planning, resisting competing attention demands for postural control, and monitoring and correcting movement errors, are necessary for functional motor control (Livesey, Keen, Rouse, & White, 2006; Roebers & Kauer, 2009). Neuro-imaging studies have shown co-activation of the cerebellum and frontal cortex upon the introduction of novel motor tasks as well as cognitive tasks, suggesting an association between the two areas and leading researchers to postulate that the link between motor

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coordination and executive functioning, mainly with respect to visuo-spatial working memory and performance speed in motor inhibition tasks, is a result of a shared underlying cerebellar mechanism. This could help explain why many children and adolescents with DCD also have EF deficits (Diamond, 2000; Michel, Roethlisberger, Neuenschwander, & Roberts, 2011; Rigoli, Piek, Kane, & Oosterlaan, 2012).

Developmental Coordination Disorder (DCD) is a severe impairment of motor coordination that significantly interferes with academic achievement and activities of daily living ([*DSM-5*] APA, 2013). There is evidence of a relationship between motor performance and executive functioning (EF) found in studies examining the functional profile of individuals with DCD (Rigoli et al., 2012), specifically, studies have shown a correlation between DCD and decreased response inhibition (Mandich, Buckolz, & Polatajko, 2002), planning and monitoring motor performance (Livesey et al., 2006; Piek et al., 2004) use of cognitive strategies (Polatajko & Mandich, 2004), and working memory, especially visuo-spatial working memory (Alloway, Rajendran, & Archibald, 2009; Ru Loh, Piek, & Barrett, 2011). Wilson, Ruddock, Smits-Engelsman, Polatajko, and Blank (2013), in performing their meta-analysis of current research regarding the understanding of DCD performance deficits, found pervasive difficulties in EF, especially, working memory, inhibitory control and executive attention (Piek et al., 2004).

The majority of existing studies of DCD and EF focus primarily on children (Alloway et al., 2009; Rigoli et al., 2012), with only several studies focusing on the young adult population. Kirby, Sugden, Beveridge, and Edwards (2008), studied 16–25 year-olds with DCD, who reported having motor difficulties since childhood, the participants reported difficulties in motor-related tasks, such as handwriting, and in executive functions such as time management, memory, organization, planning and decision making. Tal-Saban, Zarka, Grotto, Ornoy, and Parush (2012) assessed the non-academic and academic functioning of young adults with DCD including the use of executive strategies in complex task performance including goal setting, planning and self-evaluation of performance. They found significant differences between the groups, the DCD and borderline DCD groups used less executive strategies than the control group. Rosenblum (2013) evaluated 30 students with DCD and 30 students without DCD in their EF functioning as reflected in the Adult Developmental Coordination Disorder Checklist (ADC). The results showed significant deficits in EF abilities such as attention, planning and organization in young adults with DCD in comparison to the control group.

Executive functioning difficulties such as response inhibition, poor sustained attention, working memory, planning, a sense of time and emotional regulation are also characteristic of children and young adults with attention problems (Barkley, 1997; Fischer, Barkley, Smallish, & Fletcher, 2005). It has been shown that children and young adults with attention problems often have coexisting motor coordination difficulties (Fliers et al., 2010), so to, a high percentage of children with motor coordination difficulties also have attention problems (Kaplan, Dewey, Crawford, & Wilson, 2001).

Because of this overlap, Kaplan, Crawford, Cantell, Kooistra, and Dewey (2006) suggest the concept of ''Atypical Brain Development (ABD)'' or ''Minor Neurological Dysfunction,'' referring to a general underlying impairment of development. ABD emphasizes the interrelatedness of developmental disorders and the common etiology of motor difficulties, ADHD and learning difficulties (Kaplan et al., 2001).

In line with this concept, Gillberg and colleagues coined the acronym DAMP – Deficits in Attention Motor control and Perception (Gillberg & Rasmussen, 1982; Hellgren, Gillberg, & Gillberg, 1994). Children with DAMP often have executive function deficits (Gillberg, 2003) in addition to attention, motor and perceptual difficulties, an overlap that can be explained by the hypothesis that DCD and ADHD share an underlying neurocognitive mechanism relating to deficits in executive functioning (Piek et al., 2004).

In light of the paucity of research addressing executive functioning in young adults with DCD, the purpose of this study was to examine, in depth, the executive functioning profile of young adults with motor coordination deficits. A secondary purpose was to investigate the prevalence of attention problems amongst young adults with motor coordination difficulties to discern whether the observed executive functioning deficits can be attributed to the attention component.

2. Materials and methods

2.1. Participants

The initial study was conducted on a random sample of 2379 young adults from all over Israel, between the ages of 19–25 years (1081 males). The participants had no known birth complications or known psychiatric, physical or neurological deficits. Normative cognition was implied from attendance in regular education frameworks. From this large sample, three smaller study groups were identified based on the cut off scores of the Adolescents and Adults Coordination Questionnaire (AAC-Q; Tal-Saban, Ornoy, Grotto, & Parush, 2012). The DCD group, with 135 subjects at or below the 5th percentile, the borderline DCD group with 149 subjects between the 5th and 15th percentiles and the control groupwith145 individuals who scored within normal range. Groups were matched according to gender and years of education (see Tal-Saban, Zarka, et al. 2012; Tal-Saban, Ornoy, et al. 2012 for more information on the recruitment and group placement of the initial sample).

Participants were contacted again between three and four years after initial testing, between the years 2008 and 2009 (mean time from initial contact = 3.58 years; SD = 0.69) and asked to participate in the current follow-up study. Twenty-five individuals from the DCD group (18% of the original sample; mean age = 24 years, 1 month years [SD = 0.88]; 18 males), 30 individuals from the borderline DCD group (20% of the original sample mean age = 24 years, 2 months [SD = 0.98]; 18 males) and 41 individuals from the control group (28% of the original sample; mean age = 25 years, 2 months [SD = 1.91]; 20 males)