Research in Autism Spectrum Disorders 6 (2012) 726–732

Contents lists available at SciVerse ScienceDirect

Research in Autism Spectrum Disorders

Journal homepage: http://ees.elsevier.com/RASD/default.asp

Relationship between motor and executive functioning in school-age children with pervasive developmental disorder not otherwise specified

J. Schurink [a], E. Hartman [a,*], E.J.A. Scherder [b], S. Houwen [a], C. Visscher [a]

[a] Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands
[b] Department of Clinical Neuropsychology, VU University, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 21 July 2011
Received in revised form 24 October 2011
Accepted 24 October 2011

Keywords:
PDD-NOS
Children
Motor skills
Movement ABC
Executive functioning
Tower of London

ABSTRACT

This study examines the motor skills and executive functioning (EF) of 28 children diagnosed with pervasive developmental disorder-not otherwise specified (PDD-NOS; mean age: 10 years 6 months, range: 7–12 years; 19 boys, 9 girls) in comparison with age- and gender-matched typically developing children. The potential relationship between motor performance and EF in children with PDD-NOS is investigated as well. The children's motor skills were evaluated with the Movement ABC. EF, in terms of planning ability, strategic decision making, and problem solving, was gauged with the Tower of London (TOL) task. Compared with their typically developing peers, the children with PDD-NOS scored poor on the Movement ABC ($p < 0.01$) and the TOL ($p < 0.05$). They had significantly more definite motor problems than the normative sample of the Movement ABC: 43% (manual dexterity, $p < 0.001$), 25% (ball skills, $p < 0.001$), and 25% (balance skills, $p < 0.001$). There were significant inverse relationships between manual dexterity and the TOL score ($r = -0.46$, $p < 0.01$), and balance and the TOL score ($r = -0.41$, $p < 0.05$), indicating that children with a better performance on the manual dexterity subtest and the balance subtest had a better TOL score than children with a worse performance. Children with PDD-NOS have inferior motor skills, and these deficits are interrelated with planning ability, strategic decision making, and problem solving.

1. Introduction

Autism spectrum disorders (ASD), also known as pervasive developmental disorders, are a group of neurodevelopmental syndromes characterized by disturbances in social interactions (Dawson et al., 2004), language and communication (Lindgren, Folstein, Tomblin, & Tager-Flusberg, 2009; Williams, Botting, & Boucher, 2008), and the presence of stereotyped behaviors and interests (Matson, Dempsey, & Fodstad, 2009). Pervasive developmental disorder-not otherwise specified (PDD-NOS) is a type of ASD used in cases of pervasive impairment in social interaction associated with impairment in either communication or with presence of stereotyped behavior, interests or activities, but the criteria are not met for a specific disorder (American Psychiatric Association, 2000). Of all children with autism spectrum disorders, most children are categorized as having PDD-NOS, but relatively few studies have been conducted in this subgroup (Fombonne, 2005). Based on international surveys (in Europe, North America and Asia), the number of children with PDD-NOS was estimated at 2.1 per 1000 children, while the number of children with autism was estimated at 1.3 per 1000 and the number of children with Asperger Syndrome was 0.3 per 1000 (Fombonne, 2005).

* Corresponding author at: Center for Human Movement Sciences, University Medical Center Groningen, Section F, PO Box 196, 9700 AD, Groningen, The Netherlands. Tel.: +31 0 50 363 2775; fax: +31 0 50 363 3150.
E-mail address: e.hartman@med.umcg.nl (E. Hartman).

1750-9467/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rasd.2011.10.013

Even though motor skill impairments are not part of the diagnostic criteria of ASD (American Psychiatric Association, 2000), several studies established that motor impairment is common in children with ASD, including disturbances in fine motor skills (Dewey, Cantell, & Crawford, 2007; Kopp, Beckung, & Gillberg, 2010), gross motor skills (Kopp et al., 2010), and general motor incoordination (Dewey et al., 2007; Green et al., 2009; Manjiviona & Prior, 1995; Miyahara et al., 1997). Few studies specifically focused upon children with PDD-NOS. Ghaziuddin and Butler (1998) showed in a study with a small sample size ($n = 12$) that 8–15 year old children with PDD-NOS had inferior gross and fine motor skills, as measured with the Bruininks–Oseretsky test. In a more recent study, Ming, Brimacombe, and Wagner (2007) found in children with PDD-NOS, autistic disorder or Asperger's syndrome that hypotonia and motor apraxia were common motor impairments. In a study among toddlers, it was shown that children with PDD-NOS had both fine and gross motor problems (Matson, Mahan, Fodstad, Hess, & Neal, 2010).

Impaired motor performance of children with PDD-NOS may have a negative influence on other developmental domains, such as adaptive daily skills (Kopp et al., 2010) and communicative skills (Leary & Hill, 1996). Recent studies suggest that children's motor performance may also be related to higher-order cognitive functions, including executive functioning (EF) (Diamond, 2000; Ridler et al., 2006). EF includes higher order cognitive processes that are responsible for goal-directed behavior. These processes include different metacognitive domains such as planning, working memory, response inhibition, cognitive flexibility, and fluency. Executive functions are processed by the prefrontal cortex and it's subcortical connections (Gioia, Isquith, & Guy, 2001; Lezak, 1995). EF in individuals with ASD is studied thoroughly; EF seem to be impaired in childhood as well as in adulthood. Several studies demonstrated difficulties with cognitive flexibility (McCrimmon et al., 2011; Pennington & Ozonoff, 1996; Russo et al., 2007), planning (McCrimmon et al., 2011; Pennington & Ozonoff, 1996), inhibition (Tsai, Pan, Wang, Tseng, & Hsieh, 2011) and working memory (Russo et al., 2007). Specifically, children with PDD-NOS demonstrated difficulties with planning, cognitive flexibility, verbal fluency, and inhibition of a prepotent response (Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006).

Evidence for a relationship between motor performance and EF in typically developing populations has been found in neurobiological studies based on temporal or spatial similarities between the development of motor skills and EF. Temporal similarity signifies a parallel development of motor and cognitive processes, i.e. they develop in the same time span. For example, motor functioning as well as EF show an accelerated development between 5 and 10 years (Anderson, 2002; Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001) with a continued development into adolescence (Anderson et al., 2001; Anderson, 2002; Diamond, 2000). Spatial similarity indicates that motor and cognitive processes use the same brain structures. For instance, the dorsolateral prefrontal cortex fulfills an important role for both motor and executive functioning performance (Anderson, 2002; Diamond, 2000). As far as we know, the relationship between motor performance and executive functioning has not been examined in children with PDD-NOS and other children with ASD. The aim of the present study was to examine the motor performance, executive functioning and the relationship between these two domains in elementary school children diagnosed with PDD-NOS. The results will give insight in the existence of impairments in the both the motor and the cognitive domain in this specific subgroup of children with ASD. The results will also highlight clues for stimulating these children's motor and cognitive development simultaneously.

The children were measured on all eight items of the movement assessment battery for children creating a broad view of their motor development, including manual dexterity, ball skills and balance skill. EF was determined by measuring planning ability, strategic decision making, and problem solving. These skills are known to be essential in learning of motor skills (Seyhan & Kayhan, 1993; Smyth & Mason, 1997). Based on the temporal and spatial similarities between motor performance and EF that have been found in neurobiological studies (Anderson et al., 2001; Anderson, 2002; Diamond, 2000) we hypothesized that motor performance is positively related to EF in children with PDD-NOS.

2. Methods

2.1. Participants

Lecavalier, Gadow, DeVincent, Houts, and Edwards (2009) showed in children with ASD, including a large sample of children with PDD-NOS, that symptoms are heterogeneous and they change with development. The three core features of ASD, as outlined by the DSM-IV, were best reflected in school-aged children with normal intelligence (IQ $>$ 70) (Lecavalier et al., 2009). It is already known that children with intellectual disabilities have problems performing gross motor skills (Hartman, Houwen, Scherder, & Visscher, 2010; Westendorp, Houwen, Hartman, & Visscher, 2011). Therefore, we conducted the present study in 7–12 year old children with PDD-NOS, with normal IQ levels, and without co-morbidities like attention-deficit/hyperactivity disorder (ADHD).

The participants were recruited from two primary special-needs schools located in the northern regions of the Netherlands. Children are admitted to these schools in the case of learning disabilities (reading disorders, language disorders and/or mathematical disorders). Part of the children have developmental disorders, like ASD or ADHD and/or they have intellectual disabilities (IQ $<$ 70).

Twenty-eight participants diagnosed with PDD-NOS participated in the study. They all had received a formal diagnosis by a professional (e.g. Developmental Pediatrician, Psychologist, and Psychiatrist) on the basis of DSM-IV-TR criteria (American Psychiatric Association, 2000). In addition, the Children's Social Behavior Questionnaire (CSBQ; Hartman, Luteijn, Serra, & Minderaa, 2006; Luteijn, Jackson, Volkmar, & Minderaa, 1998) was used, which is developed to measure symptoms of PDD-NOS